A COMPARISON OF HEURISTIC AND OPTIMIZATION MODELS FOR BANK ASSET PORTFOLIO ADJUSTMENTS

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ADJUSTMENTS

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PREFACE

This study explored the predictive abilities of three models of bank asset portfolio behavior. The objective of the study was to find out which of the three models was the most accurate predictor of a banks asset portfolio. Four banks were studied using spectral analysis, Hannan's inefficient method of time series analysis, linear programming, quadratic programming and the root mean square error.

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INTRODUCTION

Funds flow into a bank as cash through the deposit categories. Some of these funds are then placed into other asset categories. This study is concerned with the conversion by the bank of the funds from cash to other asset categories, i.e., the adjustment process of the asset portfolio.[1] The study is not concerned with why a bank adjusts its asset portfolio in response to an adjustment in its deposit portfolio, only that it does. The purpose of this study is to compare the predictive abilities of different models of the adjustment process for a bank's asset portfolio.

All of the models in the literature can be related to one of three basic theories of bank asset allocation (135). The three basic theories of how a bank allocates its assets, i.e., adjusts to its asset portfolio, are pool-of-funds, asset allocation, and optimization.

The pool-of-funds approach considers that the bank obtains its funds from a number of sources. The basic idea underlying this theory is that all funds should be placed into one large pool. Allocations are then made from this pool to meet the bank's demand for funds. Funds would not be allocated on any particular basis from the pool, i.e., no attempt is made

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[1]This study is concerned with the conversions that both increase and decrease the deposit and asset categories.

to match the maturity of the funds used to acquire a particular asset with the maturity of the asset. This approach places heavy emphasis on bank liquidity and less emphasis on bank profitability. It is a result of the "real bills" thinking of commercial banks in the 1950s and 1960s (84, 114, 124, 135).

The asset allocation approach (135) was proposed in an attempt to eliminate the deficiencies of the pool-of-funds theory. This approach considers that the liquidity needed by the bank should be related to the source from which the funds came. This theory attempts to distinguish funds according to the velocity, i.e., turnover, of the sources. Once the turnover rate of the sources is determined an attempt is made to match sources (liabilities) and uses (assets) with similar velocities, i.e., maturities. The main advantage of this approach is that it gives more consideration to bank profitability while still considering bank liquidity. The major disadvantage of this theory is that it fails to consider the importance of the minimum liability balances held by the bank.

The optimization approach (2, 8, 20, 26, 28, 35, 45, 63, 77, 84, 115, 120, 127, 128, 130, 135, 139, 145, 148, 150), also known as the management science approach, gives to the bank a specific objective not set forth in the pool-of-funds or asset allocation approaches. In the literature this objective is usually profit or utility maximization. This approach differs from the first two in that it emphasizes the objective of bank management and not the actual adjustment process of the portfolio. The bank uses whatever adjustment process it wishes to achieve its objective.

Using these three approaches researchers have developed and tested numerous models of how a bank behaves, i.e., adjusts its asset portfolio. The majority of the work has used the optimization approach. The question which needs to be answered is, which of the postulated forms of bank behavior, i.e., models, best describe current bank management behavior.

The term, best, implies that there is a criterion by which all of these models can be judged. The criterion proposed in this study is the predictive ability of the models. The predictive ability of a model was chosen as the criterion by which the models are to be judged because if a model cannot predict, it has not captured all of the crucial and essential elements necessary to describe the process being modeled. If a model cannot predict, within some normal range for error, the future asset portfolio of a commercial bank, then it has failed to capture the actual adjustment process.

This research will adjudge the question presented in the previous paragraph, i.e., which model is the most descriptive of bank behavior. The three approaches which banks may use to adjust their asset portfolio will be modeled and tested in their pure form. Variations of the three approaches, suggested in the literature (34, 35, 84), will also be modeled and tested. Obviously, the study's findings will also have implications about the validity of the three basic approaches for describing bank portfolio adjustments.

This study is only concerned with the predictive ability of certain models of bank behavior, i.e., how a bank adjusts its asset portfolio. The study will not include any chance constrained or goal programming models of bank behavior, nor will it use multiperiod optimization models of the portfolio adjustment process.

CHAPTER II

LITERATURE REVIEW

The purpose of this section is to review previous studies which have examined the adjustment process of a bank's asset portfolio. It will present the reader with an overview of the previous research so that he can relate the current effort to work in this area.

The research covered will be divided into three groups. Each group will represent a different approach to a bank's portfolio adjustment process. The first section of articles will consist of those studies which view the adjustment as an optimization problem. This theory postulates that a bank will adjust its asset portfolio in an attempt to maximize an objective which the bank is trying to achieve. It also assumes that the bank is limited in preserving this objective by constraints imposed upon it from different quarters. The majority of the research has been in this area. The second section presents the articles which consider the bank to be using a pool-of-funds view of asset adjustment. This approach assumes that a bank will place all of its incoming funds into a pool of cash and near cash assets. Funds will then be drawn from this pool as they are needed by the bank. The final section introduces the research which states that banks adjusted their asset portfolio according to the asset allocation theory. This theory assumes that banks attempt to match the maturity structure of their assets with the maturity structure of their liabilities, i.e., funds flowing into the bank from short-term sources will go into short-term assets and funds from long-term sources into long-term assets.

The difference between this approach and the pool-of-funds approach is in the initial placement of the funds flowing into the bank. Bank management must decide whether to place all of the incoming funds into a pool of cash and near-cash assets or whether to place part of the funds directly into longer term loans and investments. The results of the bank management's decision will be reflected in the time it takes the bank to adjust its asset portfolio, in the profitability of the bank, and in the bank's liquidity.

Studies Using the Optimization Approach

The research using this approach is divided into five subsections. The first is a set of introductory articles which indicate that banks are using the optimization approach. The remaining four subsections present the literature according to the objective function of the study under review. The second subsection presents those articles which assume that profit maximization is the bank's objective. The third subsection contains articles which postulate that the bank is attempting to maximize its own utility. The fourth subsection hypothesizes that wealth maximization is the objective of the bank. The final subsection presents all other articles which use an optimization framework but that do not have one of the aforementioned objective functions. All of the subsections will be further subdivided into single and multiperiod studies for each objective function. The articles in each subsection will be presented in chronological order.

Introductory Articles

Anderson and Burger (5) in 1969 tested for a change in the portfolio behavior of commercial banks. The authors tested to see if bank behavior is closer to the "accomodation principle" or the "profit maximization principle". Using a two-stage multiple regression model the authors conclude that bank portfolio behavior is closer to the profit maximization principle, i.e., banks had begun to be more competitive and were more concerned with profits and less with a "real bills" type of thinking prevalent in banking prior to this time.[1]

Gillespie, Hodgman and Yancey (68) view the bank as a provider of services and not a profit maximizer. Their view of the bank is very close to what Anderson and Burger (5) call the "accomodation principle". The authors use multiple regression in an attempt to determine what variables have an effect on the level of a bank's asset categories. Considering the work of Anderson and Burger (5) and Dewald and Dreese (47) it is not surprising that none of their models gave an accurate explanation of the bank's asset categories.

Single Period Profit Maximization Articles

Orr and Mellon (120) used a two asset, i.e., reserves and loans, model to indicate the profit maximizing activities of the firm. The economic trade-off studied in this model was between the increased marginal revenue from increasing the amount of the bank's portfolio held

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[1]In the late 1940s and through the 1950s banks believed in the real bills doctrine. This doctrine said that banks should make only short-term selfliquidating loans. This concept of bank behavior focused on the liquidity of the bank with no consideration given to bank profitability.

as loans and the potential for increased cost due to the bank being less liquid after the increase in loans. Orr and Mellon indicated that the costs were in the form of a lump sum payment when the bank first becomes illiquid plus a cost of x per dollar for each dollar of reserves which the bank was short. The primary constraint placed on the bank was that the bank must meet its reserve requirements with the reserves from the present and prior periods, i.e., no sale of securities or loans to increase reserves. The authors concluded that the uncertainty of cash inflows to the bank will decrease the expansion of bank credit. Cooper (39) in a later article showed that the conclusion by Orr and Mellon was incorrect. He indicated that increased uncertainty about the bank's deposit inflows does not have to lower the expansion multiplier.

In a different type of study, Shull (142) perceived a bank as a multiple product price discriminating firm. The bank was said to be a profit maximizer, but no explicit mathematical model was presented to justify this assumption. The author views a bank as having a variety of markets and offering services in each market. The bank will expand from its most profitable markets into markets which are less and less profitable until there are no more markets in which the marginal revenue in the market exceeds the marginal cost in the market.

Haydon and Wicks (77) present a normative model which indicates the portfolio of earning assets a bank will hold to maximize its profits. The economic trade off in this model is between the true rate of interest on a loan and all the costs associated with making, administrating, and collecting the loan. The authors consider four constraint equations dealing with the nonmarketability of the loans, the maturity structure of the loan portfolio, the amount which can be loaned to one borrower and the expected risk due to the uncollectability of a loan. The authors do not consider explicitly any cash or liquidity in the cost functions for the loans which they derive. Haydon and Wicks conclude that the model provides operating principles which a bank could use to make its portfolio decisions.

In a descriptive model Bryan and Carleton (21) attempt to explain a bank's short-term portfolio adjustments to monetary policy. The authors use a partial adjustment model to describe the bank's behavior. The bank is postulated to be constantly trying to minimize its holding of excess reserves. The authors do not say why the bank is minimizing its holdings of excess reserves, but it is assumed that the bank is trying to minimize its holdings of non-earning assets. This does imply that the bank's objective is profit maximization. The bank's decision variable is its non-earning reserves. The bank changes its non-earning reserves in response to the yield it foregoes on the asset which is the closest substitute. The bank's earning reserves are then changed in response to the bank's shift in its non-earning reserves.

DePamphilis (45) presents a model of the short-term commercial bank adjustment process. Assuming that the objective of the bank is to maximize its profits, the author sets up the short-term model with an objective of minimizing the cost of the short-term adjustment. The minimization is subject to a balance sheet and a net liquidity constraint. The author tests the model using ordinary least squares regression and finds that is gives an adequate explanation of the short-term adjustment behavior of a commercial bank.

Beazer (8) uses a single period linear programming model repetitively for 16 to 27 periods for 14 banks to determine if the model has any predictive ability. The model's objective function is to maximize the expected returns of the 20 asset categories times the amount in each asset category. The objective function is restricted by nine constraints. The constraints are for (1) capital adequacy, (2) required reserves, (3) restricting the amount in real estate loans, (4) pledged assets, (5) balance sheet balancing equations with transaction balances and balances with other banks, (6) maintaining enough capital to cover risk assets, (7) liquidity, (8) balance sheet balancing equations with other assets and cash in the process of collection, and (9) making sure total assets in the solution do not exceed the actual total assets of a particular bank. In testing the predictive ability of the model the author regressed the predicted asset values on actual asset values for the 14 banks. The regression revealed that over half of the regression coefficients were significantly different from zero. This indicates that the model was not a good predictor of the decisions made by bank managers. The author notes that the inability of the model to accurately predict could be due to lags in the adjustment process.

Beazer's affirmation that lags in the allocation process could have reduced the predictive ability of his model is only one of several reasons for the model's poor predictive performance. The failure of this type of model to consider the liability side of the balance sheet, either in absolute or in difference form, is also a cause of the model's inability to predict accurately. Further, the model ignores the multiperiod aspect of the allocation process. It can also be said of this and other optimization models that they require information which is impossible to obtain, i.e., the true return on a particular asset, etc.

Hester and Pierce (84) provide a model of bank behavior similar to Walker (150), Beazer (8), and Haydon and Wicks (77). Their objective is to maximize the bank's profits subject to a balance sheet constraint. The authors discuss legal, managerial, and risk constraints but do not include them explicitly in the model. The bank responds to changes in deposits and interest rates by adjusting its portfolio of assets. The model is tested using ordinary least squares regression. The deposit and other variables are regressed on the asset categories to find three things. First, what variables have the greatest effect in determining the levels of the asset categories? Second, what time lag is there in the adjustment process, i.e., how long does it take funds from deposits to flow into the asset categories? Finally, which types of deposits are most closely correlated with which asset categories? Hester and Pierce, using a pool-of-funds approach, assume that the funds flowing into the bank go first into cash and near cash assets, second into securities, and finally into loans. The study's results confirm this lag structure. The studies results also indicate that the composition and history of the bank's deposits are important determinants of the asset portfolio structure. The authors find that the lag structures are stationary over time and that the responses to demand and time deposit inflows are different for different assets. They further conclude that the cost of asset adjustment is an important determinant of portfolio composition. Hester and Pierce (84) also confirm the results of Kane and Malkiel (96), Dewald and Dresse (47), Stuble and Wilderson (146), and Frazer and Rose (62), i.e., that the predictability of a bank's deposits is an important determinant of the composition of the bank's asset portfolio.

It is important to note that the assumption by the authors that funds flow first into cash and near cash assets is a pool-of-funds assumption. The authors continue to use a pool-of-funds approach when they regress both short- and long-term deposits on each asset category, implying that neither a particular deposit category nor a particular component of any deposit category is important in determining a particular asset category. Their use of all deposit maturities to explain each asset category is very consistent with the pool-of-funds approach. It is also interesting to perceive that the authors, while giving the bank an optimization objective, use a pool-of-funds allocation procedure to test their model.

Multiperiod Profit Maximization Articles

Thore (148) considers the bank's need to hold cash and short-term cash assets to buffer against adverse changes in deposits. He uses chance constrained two stage programming under uncertainty to determine the maximum level of the bank's profits. His objective function, like that of Orr and Mellon (120), consists of a component for the increased profits due to increased lending by the bank and a component for the possible increase in costs due to the decrease in the bank's liquidity position. The objective function is then constrained so that any change in the bank's excess reserves will have to equal any borrowing done by the bank plus any increase in excess reserves caused by an increase in deposits. Thore points out that two stage programming is superior to the "inventory theoretic approaches" used by Orr and Mellon (120), Cooper (39), and Porter (127). The technique is better because (1) it provides automatic access to a dual program and the information which it can provide, and (2) the programming model can be extended to cover more constrained situations with less effort than can the inventory theoretic models.

Following the work of Charnes and Thore (28) and Thore (148), Fried (63) uses chance constrained programming to model bank behavior. The model assumes the bank is trying to maximize expected profit subject to liquidity, reserve requirements, pledged assets and budget constraints. The author's attempt to incorporate imperfect asset markets and liabilities which are not under the control of the bank into the model is similar to the work of Charnes and Thore (28). Fried generates asset portfolios using his model and compares them to actual bank portfolios. He concludes that the findings are not consistent with his hypothesis, i.e., the banks do not behave according to his model. This work, like Beazer (8), indicates that optimization models are not good predictors of bank behavior.

In a classic article Chambers and Charnes (26) develop a model for maximizing the profits from a bank's asset portfolio over time. They use a dynamic programming model which is tied together over time by coupling constraints. The model has two intraperiod constraints. The first is to make sure that a bank meets the reserve requirements set by the regulatory authorities. The second provides that the bank maintain a balanced portfolio so that it meets the leverage requirements set by the Federal Reserve Bank examiners. The model allows the bank to choose its profit maximizing asset portfolio given that it knows its demand and time deposits, the level of interest rates and the bank's net worth for future time periods. One advantage of this model formulation is that it will immediately provide a dual solution to the portfolio problem indicating the incremental value of adding one unit of that asset to the optimal portfolio.

The model presented by Walker (150) assumes that the bank adjusts its asset portfolio; cash, investments, loans, fixed assets, and other assets; as a reaction to changing interest rates, liquidity needs, and growth. Walker assumes that the objective of the bank is to maximize profits subject to a variety of constraints. The tool chosen to analyze the bank's behavior is a linear recursive programming model. Recursive programming differs from dynamic programming in that it does not optimize over the entire time horizon under study; rather it optimizes period by period. The author describes the interactions among the variables which are controlled by the bank in a series of single-equation least squares regressions. The regression equations are used to determine the actual parameters for a particular bank. These regression equations are then put into a reduced form and used as the constraints in the recursive programming format.

Stone and Reback (145) provide a model for portfolio revisions. The model differs from others in that it introduces goal programming to the portfolio revision problem and considers transaction costs in determining the optimum revision for a portfolio. The authors introduce both a single and multiperiod model. In both models the objective is to maximize "the increase in risk adjusted expected returns less the transaction costs per dollar incurred in obtaining the improvement in expected return". Both models have four constraints. The first is a non-negativity constraint, i.e., purchases and sales of a particular asset must be greater than zero. The second restricts the amount that can be spent on new assets to the amount sold less transaction costs.

The third constraint prohibits short sales. The final constraint forces diversification among the assets such that all the funds will not flow into one asset. In conclusion, the authors point out that their models provide good approximations to the results obtained from quadratic programming models used in other portfolio revision studies.

Single Period Utility Maximization Articles

Kane and Malkiel (96) discuss a model of bank behavior which will maximize the expected utility of the bank. The utility of the bank managers is expressed in terms of a mean-variance portfolio framework. The only constraint in the model is a balance sheet constraint. Their purpose was to show that the tenet of the availability doctrine, i.e., that lenders in response to credit policy are the most important factor in controlling the amount of credit in circulation, is not correct. The authors conclude that an increase in deposit variability increases the risk exposure of the bank. They also conclude that it is better for a bank to increase its risk exposure, by making more loans than a bank deems optimum, as well as its profitability. This is opposed to denying the loan request and increasing risk exposure, due to the loss of customer goodwill, and not increasing profits.

Michaelsen and Goshay (115) postulate a utility maximizing behavior on the part of financial intermediaries. The authors differ from previous research in that they hypothesize "an institutional utility function common to all firms in a given financial industry". The result being that all firms have similar policies toward the risk characteristics of their equity. The authors also point out that it is the concept of "homemade" diversification which allows investors to be indifferent to the asset structure of the intermediary. Therefore, investors risk preferences have no influence on the financial intermediaries portfolio decisions. Investor indifference is what causes the authors to postulate a common utility function in an attempt to explain how one firm determines its risk class. Sharpe's model is used as the model of institutional behavior. It allows the introduction of risk constraints placed on the maximizing behavior of the firm by the common utility function. The authors use regression analysis to test their model in the property and casualty insurance industry. They conclude that a common institutional utility function does exist in this industry.

Similar to many of the previous studies, Russell (139) describes a model in which the bank is to maximize its expected utility. The bank is to have an inflow of deposits which is to be a random variable but is to be ignored in determining the bank's expected utility. The bank will adjust its portfolio based upon the expected future returns of its assets. The decision variables are the assets within the bank's portfolio. The author notes that seldom are the actual and optimal values for the assets equal. His contribution to the field is in postulating a Markov process to explain the adjustment process from the actual toward the optimal portfolio. The transition probabilities are represented by the difference between the yield on a particular asset and all other assets in the portfolio. The higher the yield on asset i relative to the yields on the other assets in the portfolio, the greater the probabilities will transfer to that asset. Russell does an Ordinary Least Squares (OLS) regression to determine if the variables postulated in the model actually do contribute to the adjusting of the asset portfolio. He concludes that the amount of an asset in the previous period, the yield on the asset, and the deposit inflow for this period definitely affect the level of a particular asset category.

Aigner and Bryan (2) present a short run adjustment model of a bank's asset portfolio. Their model maximizes the total utility of the bank considering the short-run decision variables, i.e., excess reserves, Federal funds and investments. The model has only one constraint which is a modified balance sheet restriction, i.e., modified such that the decision variables on both the asset and liability sides are short term. The model implicitly considers risk and liquidity but does so in what the authors call the "subjective returns", i.e., utility. The authors test their model using an OLS regression. While the empirical results generally agree with their theory, the results were such that they were dissatisfied with their empirical model.

Klein (97) introduces a normative model of banking behavior which allows for competition and market structure. The model's main contribution is that it considers the interest elasticity of asset supply to the bank, i.e., an increase in loans will cause the bank to have a reduction in the marginal returns on the loans. The model maximizes expected utility by maximizing the bank's rate of return on equity. The author ignores all constraints other than a balance sheet constraint. Two ignored constraints which the author states would definitely change the formulation of the model are reserve requirements and interest ceilings on deposits. Using a three asset portfolio consisting of loans, cash and government securities, Klein finds that the bank should continue to make loans until the marginal return on loans equals the average expected return on government securities. He also finds that cash is held until its marginal return is equal to the expected return on government securities.

Pyle (130) considers the portfolio problem in financial intermediaries while abstracting from the liquidity and transactions demand problems of the intermediaries. His model has an objective function which is referred to as the intermediaries preference function and is expressed in terms of the mean and variance of the firm's terminal wealth. The maximization of the objective function is constrained only by a balance sheet equation. The portfolio in the model contains three assets which the author does not specify, but they are assumed to be cash, securities, and loans. The solution to the model indicates that intermediation is more likely to occur in the following situations: (1) the larger the risk premium on loans and the smaller the risk premium on deposits, (2) the greater the positive dependence between loans and deposit returns, and (3) the smaller the standard deviation of loan yields and the larger the standard deviation of deposit yields.

In this article, Hyman (91) develops a normative model which indicates the optimal allocation and size for a bank portfolio. The model is designed to maximize the expected utility of the bank by maximizing the expected yield on an asset per unit of risk. The only constraint in the model is the individual bank's degree of risk aversion. The author shows that the financial intermediaries' decision on the portfolio allocation and size are in fact separable, i.e., they can be treated as two separate effects. Using a quadratic utility function Hyman shows that the two effects are in fact similar to the income and substitution effects of traditional microeconomics. The author points out that any intermediary changing the composition of its portfolio because of changes in the risk-return parameters will be faced with the two effects. In summary, Hyman indicated that the mean-variance portfolio model cannot completely capture all of an intermediary's behavior patterns because of the restrictive assumptions in the model.

Silverberg (144) uses a mean-variance model to show that banks respond to increasing deposit costs by increasing their holding of more risky assets and thereby raising their return. This article like Anderson and Berger (5), Gillespie, Hodgeman, and Yancey (68) and Dewald and Dreese (47) shows that banks are very profit conscious. They are profit conscious to the point that they will adjust their asset portfolios to maintain what bank management considers to be an acceptable level of profit. This research does not imply profit maximization by the bank, only a definite consideration of profits.

Single Period Wealth Maximization Articles

Melitz and Pardue (113) present a strictly economic analysis of the demand and supply of bank loans. Assuming that the bank's objective is to maximize its own present value, the authors derive demand and supply equations for the bank's loans. The bank is limited only by a budget constraint. The authors then test their theory using both single stage and simultaneous equation regression models. They find that all variables in both the supply and demand equations are significant in explaining the supply and demand for commercial bank loans.

Pringle (128) uses the Sharpe-Litner-Mossin (SML) capital asset pricing model to develop a one period-two asset normative model of bank portfolio behavior. The model's main contribution to the portfolio adjustment process is its removal of the perfect market assumptions and the inclusion of imperfect market assumptions in the derivation. The model is an unconstrained wealth maximization model, i.e., it maximizes the present value of the end of period cash flows. The optimal loan balance for any bank is found to be at the point where the marginal revenue from the loan portfolio is just equal to the marginal cost of the risk to the bank of holding that loan portfolio.

Multiperiod Wealth Maximization Articles

Cohen and Hammer (35) criticize the asset allocation approach to bank asset management and present a model used by the Bankers Trust Company of New York. The model:

> . . . maximizes the present values of the net income stream plus realized capital gains (and losses) during the planning horizon plus the present value of the stockholders' equity during the final period of the planning horizon (35, p. 156).

The model uses both intra-period constraints and inter-period constraints. The intra-period constraints are the same for each period and include risk or leverage constraints, a basic balance sheet constraint, safety and liquidity constraints and constraints which arise due to the "economic and institutional realities of the market place". The inter-period constraints occur over the planning horizon of the model and are constraints on the flow of balance sheet accounts, constraints on the capital funds in the bank and constraints on the interrelationships between the services provided by the bank, i.e., making a loan at a lower rate to attract a customer's deposit. This model uses linear programming models to determine the user's portfolio adjustments.

Other Optimization Articles

Porter (127) derives a normative model of a bank's portfolio behavior. The author's model is a one period-three asset, i.e., cash, securities and loans, formulation. Porter assumes the bank is attempting to maximize the "expected additions to net worth". He also assumes that the variance of the returns on the asset categories is not to be included in his model. Porter points out that the purpose of including the variance in a model is to help explain diversification. His model is not concerned with diversification but with the maximization of the additions to net worth. The author shows how banks can be in one of three stages relative to handling an outflow of funds. He then formulates a relationship between the change in net worth and the pertinent earning assets for each stage in which the bank might find itself.

Silber (143) models a bank's portfolio behavior in an attempt to find which bank assets are substitutes and which are compliments. The study is strictly positive in nature. The author derives supply and demand equations for a bank's assets and liabilities and uses a two stage-least squares regression model to find the relationships between bank assets and liabilities. His study differs from others presented in that the bank's decision variable for loans is the rate the bank will charge on the loans. The model assumes that the bank's deposits and quantity of loans are constraints on the bank's adjustment process.

Studies Using the Pool-of-Funds Approach

The literature is not replete with studies using this theory. The two studies presented here do not specifically state a pool-of-funds theory, but their assumptions about how funds flow through a bank indicate they feel a bank acts according to this theory. The reason for the lack of research could be because the pool-of-funds theory does not postulate a specific objective of bank management. The theory describes or hypothesizes about bank behavior without a statement of why this behavior is observed. As in the previous section, the articles are presented in chronological order.

Pierce (124) using time series data, does an empirical study about the allocation of deposit funds to the various asset categories of a bank. He uses a reduced form regression model for three major asset categories, i.e., reserve assets, investments and loans. He postulates that inflows of deposits will initially go into reserve assets and subsequently into various investment and loan categories. The author also postulates that funds will move out of reserve assets and into investments very quickly while taking longer to move from reserve assets to loans. His model indicates that the level of assets in time period t will depend upon: (1) the bank's level of demand deposits, (2) its level of time and saving deposits, (3) the expected return on the asset, (4) the variability of the expected return, (5) the bank's level of capital, (6) its income, and (7) a variable representing time. The author estimates outcomes for the same model using varying time horizons for the independent variables and finds that the model does not allow strong conclusions to be drawn about the adjustment process. He concludes the poor results are due to the reduced form character of the equations and poor data. Serially correlated residuals prevented the author from making any tests of significance.

Melnik (114) uses a first difference model to explain a bank's short term portfolio behavior. His interpretation of the OLS regression coefficients indicate which variables are important in determining the short term adjustments of a bank's asset portfolio. The author concludes that the initial adjustment of a bank's portfolio is in the more liquid assets. He also concludes that changes in relative interest rates of the assets and the deposit variability are important determinants of a bank's asset portfolio adjustments.

Studies Using the Asset Allocation Approach

No studies could be found which implied the use of the asset allocation theory. The lack of research in this area could be for two reasons. First, like the pool-of-funds theory, the asset allocation theory does not postulate any specific objective of bank management. It conjectures about bank behavior without attempting to explain why the behavior is observed. Second, Cohen and Hammer (35), in an early article on bank asset allocation, criticize the asset allocation theory for two reasons. They point out that the theory does not differentiate between "the volatility of a particular dollar of deposit and minimum amounts and stability of those deposit balances" (35, p. 156). Second, the authors say that the theory ignores the interrelationship between a bank's source of funds and its uses, particularly the feedback mechanism between a bank's uses and its sources.

Conclusion

The review shows that there are many ideas about a bank's asset portfolio adjustment process. Yet no research has been done to compare the predictive abilities of the different types of models about bank portfolio behavior, i.e., no work has been done to find that model which is most descriptive of actual bank behavior. The only general review about bank portfolio adjustments was by Pyle (131), and it was more concerned with the different formulations of the models than with their predictive ability. This research will provide additional insight into the predictive abilities of the models as well as indicating which of the three approaches about bank portfolio management most closely followed by commercial banks.

The review also indicates that the two most widely assumed objectives of portfolio adjustment behavior are single period profit maximization and single period utility maximization. In the majority of utility maximization studies, utility is defined in a risk-return sense, i.e., the bank maximizes its utility by optimizing a risk-return relationship. Therefore, the two optimization objectives used in this research will be the same as those most often used in the literature.

The review does substantiate that little work has been done using the pool-of-funds and asset allocation approaches. Even though these approaches are largely ignored in the current literature, it does not mean that banks do not behave in a manner postulated by one or both of the two approaches.[2] This study will include models designed to test the flow of funds through a bank to determine if either approach correctly describes current bank behavior.

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[2] The pool-of-funds and asset allocation approaches were used before the optimization approach to explain bank behavior. They do not provide the bank with an overall objective, such as profit maximization, nor are they as economically rigorous as the optimization approach.

CHAPTER III

HYPOTHESES AND MODELS

The information presented in this section provides the basis for examining the adjustment process of a bank's asset portfolio. The major hypotheses to be tested as well as the models for testing the hypotheses are presented. Each hypothesis postulates a different form of bank behavior and is represented by a different model.

Hypotheses

This study has seven major hypotheses. Each one assumes a different form of bank behavior. The first five hypotheses specify a way in which the bank adjusts its asset portfolio. They do not specify an objective which the bank is trying to achieve by the adjustment. The last two hypotheses do specify an objective which bank management is trying to achieve by adjusting its asset portfolio. The hypotheses should be considered in light of the three theories of bank asset allocation, i.e., pool of funds, asset allocation and optimization, presented in the first section of this paper.

All hypotheses presented have been explicitly or implicitly implied in the literature, as shown in the previous chapter. Hypotheses one through five are designed to answer two questions. The first is, does a lag structure exist within the portfolio allocation process of commercial banks? The second is, which of the two approaches of asset portfolio adjustment, i.e., asset allocation or pool-of-funds, best described the flow of funds through a bank? The means to answer these two questions will be presented in the models portion of this chapter. Hypotheses six and seven are designed to test the optimization approach to asset allocation presented in the introduction.

All of the first five hypotheses will provide a test of the lag structure of the adjustment process. Hypotheses one and two will test the asset allocation theory of bank behavior. Both hypotheses assume the bank is only considering the maturity structure of the deposits in allocating funds to the assets. Hypotheses four and five, in line with Cohen and Hammer (35) and Hester and Pierce (84), assume that regardless of the maturity structure or variability of a particular deposit category there will always be some portion of that category which is available to the bank for investment. These hypotheses assume that the bank does not adjust its asset portfolio according to the maturity structure of the deposits but rather according to the permanent or transitory nature of the deposits. With these hypotheses, portions of short-term deposits, i.e., the permanent component, would go into long-term assets and portions of long-term deposits, i.e., the transitory component, would go into short-term assets. Hypothesis three is designed to test the pool-of-funds approach to a bank's asset portfolio adjustment process. This hypothesis in conjunction with hypotheses one and five will indicate first, if banks use a pool-of-funds approach and, second, how banks allocate funds from the pool to the asset categories.

Hypotheses six and seven assume that the bank is behaving according to the optimization theories of asset allocation. Hypothesis six represents the banks as attempting to maximize its profit subject to a set of specified constraints. Hypothesis seven is a modification of the optimization theory in that it allows for the explicit incorporation of risk into the assumed bank behavior.

The major hypotheses of this paper are:

Hypothesis No. 1

H_0: Funds which flow into the bank as deposits with a long-term maturity will not be placed into asset categories which have a long-term maturity.

H_1: Funds which flow into the bank as deposits with a long-term maturity will be placed into asset categories which have a long-term maturity.

Hypothesis No. 2

H_0: Funds which flow into the bank as deposits with a short-term maturity will not be placed into asset categories which have a short-term maturity.

H_1: Funds which flow into the bank as deposits with a short-term maturity will be placed into asset categories which have a short-term maturity.

Hypothesis No. 3

H_0: All funds flowing into the bank as deposits will be placed into asset categories which have a short-term maturity.

H_1: All funds flowing into the bank as deposits will not be placed into asset categories which have a short-term maturity.

Hypothesis No. 4

H_0: The transitory component of the short-term deposits and/or the transitory component of the long-term deposits will not be allocated to asset categories which have a short-term maturity.

H_1: The transitory component of the short-term deposits and/or the transitory component of the long-term deposits will be allocated to asset categories which have a short-term maturity.

Hypothesis No. 5

H_0: The permanent component of the short-term deposits and/or the permanent component of the long-term deposits will not be allocated to asset categories which have a long-term maturity.

H_1: The permanent component of the short-term deposits and/or the permanent component of the long-term deposits will be allocated to asset categories which have a long-term maturity.

Hypothesis No. 6

H_0: A bank will adjust its asset portfolio in such a way as to maximize bank profits. It will make the adjustments restricted by legal, regulatory and managerial constraints.

H_1: A bank will not adjust its asset portfolio in such a way as to maximize bank profits. It will make the adjustments restricted by legal, regulatory and managerial constraints.

Hypothesis No. 7

H_0: A bank adjusts its asset portfolio in such a way as to minimize its risk for a given level of return or maximize its return for a given level of risk.

H_1: A bank will not adjust its asset portfolio in such a way as to minimize its risk for a given level of return or maximize its return for a given level of risk.

Models

The purpose of these models is to test the major hypotheses presented in the previous section. They are formulated to correspond with the three basic asset allocation theories, i.e., pool-of-funds, asset allocation and optimization; as well as modifications of these theories found in the literature. The models, when tested, should indicate which of the three theories is the best predictor of bank behavior.

There are two basic classes of models about a bank's asset portfolio adjustments to be compared in this research. They are heuristic and optimization models. The research will examine the predictive ability of five heuristic stochastic models as well as the predictive ability of a linear and a non-linear optimization model. In all there are seven models whose predictive ability will be tested. Each model will test a different hypothesis, i.e., form of bank behavior, from the previous section.

Heuristic Models

There are five heuristic stochastic models. Each postulates a different behavior by a bank in handling the adjustments of its asset portfolio. Heuristic models have been used frequently to describe bank portfolio adjustments

The five heuristic models will all be of the basic form:

$$ {}_e A_{\ell,t} = \sum_{s_e = b_e}^{-b_e} W_{s_e} L^{s_e} \left(\sum_{L=1}^{m} D_{j,t} \right) + {}_e U_{\ell,t} \tag{1} $$

where:

${}_e A_{\ell,t}$ is the change in the ℓ^{th} asset for the e^{th} representation in the t^{th} time period,

W_{s_e} is the weight assigned to the change in the j^{th} deposit for the e^{th} representation in the $(t-s)^{th}$ time period,

L^{s_e} is the lag operator,[1]

$D_{j,t}$ is the change in the j^{th} deposit in the $(t-s)^{th}$ time period,

${}_e U_{\ell,t}$ is white noise,

and

m is the total number of deposit categories which have an effect on ${}_e A_{\ell,t}$,

$b_e = 0, 1, \ldots, N$; $N < 00$ and is the lead or lag period of the operation L^{s_e},

e is a particular representation or design for each model.

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[1]To show how the lag operation works consider the following from Engle (53). A general way to think about the relations between two time series is in terms of a bivariate distributed lag model of the form:

$$ Y_t = \sum_{j=r}^{-r} w_j X_{t-j} + E_t $$

This model can be rewritten in the form of a lag operator L, as:

$$ Y_t = \sum_{j=r}^{-r} w_j L^j X_t + u_t $$

where leads as well as lags are allowed and L^{-1} is interpretated as a lead operator.

This model indicates that the amount of any asset category is a distributed lag function of the deposits or a summation of the deposits from previous periods. As stated in the hypotheses section of the chapter, each model will answer two questions. The first question is, is there a lagged relationship between deposits and assets, and if so, what is that relationship? The second question is, which of several postulated forms of bank asset adjustment behavior do banks actually follow?

Long Term Group Allocation Model (LGAM). This model is designed to test hypothesis 1 in the previous section. It is a test of either the asset allocation or a modified pool-of-funds approach. Both are presented in the introductory section of this paper. In this model the bank is assumed to allocate long-term deposit groupings to asset categories with a long-term maturity. The formulation of the model is:

$$_{e}A_{k,t} = \sum_{r_e = h_e}^{-h_e} W_{r_e} L^{r_e} \left(\sum_{z=1}^{m} D_{z,t} \right) + {}_{e}u_{k,t}[2] \tag{2}$$

where:

$_{e}A_{k,t}$ is the change in the k^{th} long term asset for the e^{th} representation in the t^{th} time period,

W_{r_e} is the weight assigned to the change in the z^{th} deposit for the e^{th} representation in the $(t-r)^{th}$ time period,

L^{r_e} is the lag operator,

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[2]In all the models to be presented there are n short term assets and q long term assets, such that n + q = g, total assets. Also, there are a long term deposits and d short term deposits such that a + d = m, total deposits.

$D_{z,t}$ is the change in the z^{th} long term deposit in the $(t-r)^{th}$ time period,

${}_eu_{k,t}$ is white noise,

e is a particular representation or design for each model,

and

a is the total number of long term deposits which have an effect on ${}_eA_{k,t}$

$h_e = 0, 1, \ldots, M;\ M < \infty$ and is the lead or lag period of the operator L^{r_e}.

In this model the bank makes its adjustments on a deposit category by deposit category basis only. All of one long-term deposit category is assumed to flow into one or several asset categories with a similar maturity. There is no division of the deposit categories, i.e., into permanent or transitory components, prior to their allocation.

<u>A Short Term Group Allocation Model (SGAM).</u> This model is designed to test hypothesis 2 in the previous section. It is a test of the asset allocation approach presented in the introductory section of this paper. This model postulates that a bank will allocate its short-term deposits to short-term assets. The formulation of the model is:

$$ {}_eA_{i,t} = \sum_{s_e=b_e}^{-b_e} w_{s_e} L^{s_e} \left(\sum_{z=1}^{d} D_{v,t} \right) + {}_eu_{i,t} \qquad (3) $$

where:

${}_eA_{i,t}$ is the change in the i^{th} short term asset for the e^{th} representation in the t^{th} time period,

w_{s_e} is the weight assigned to the change in the v^{th} deposit for the e^{th} representation in the $(t-s)^{th}$ time period,

L^{s_e} is the lag operator,

$D_{v,t}$ is the change in the v^{th} short term deposit in the $(t-s)^{th}$ time period,

$e^u{}_{i,t}$ is white noise,

e is a particular representation or design for each model,

and

d is the total number of short term deposits which have an effect on $e^A{}_{i,t}$,

$b_e = 0, 1, \ldots, N;\ N < \infty$ and is the lead or lag period of the operator L^{s_e}.

This model indicates that a bank will make its adjustments on a deposit category by deposit category basis only. No division of the deposit categories prior to allocation will be made. All of a particular short-term deposit category is assumed to go into one or several asset categories with a similar maturity.

A Short Term Funds Model (SFM). The model in this section is designed to test hypothesis 3 in the previous section. It is a test of the pool-of-funds theory presented in the introductory portion of this paper. This model in conjunction with the LGAM and LCAM, will be used to test for a modified pool-of-funds behavior by the banks. A pure pool-of-funds approach would not be concerned with how funds are allocated from the pool. This model in conjunction with the LGAM and LCAM, however, does specify how funds are to flow from the pool.

The test for a pool-of-funds behavior on the part of the banks is a two step process. The first step consists of comparing this model with the SGAM and SCAM models to see which best specifies the bank's adjustment behavior. If this model best describes bank behavior, then the second step is to compare the LGAM and the LCAM to see which best describes the way in which funds are allocated from the pool. This process will be explained in more detail at the end of this section.

The formulation of the model is:

$$_{e}A_{i,t} = \sum_{s_e=b_e}^{-b_e} w_{s_e} L^{s_e} \left(\sum_{j=1}^{m} D_{j,t} \right) + {}_{e}u_{i,t} \tag{4}$$

where:

$_{e}A_{i,t}$ is the change in the i^{th} short term asset for the e^{th} representation in the t^{th} time period,

w_{s_e} is the weight assigned to the change in the j^{th} deposit for the e^{th} representation in the $(t-s)^{th}$ time period,

L^{s_e} is the lag operator,

$D_{j,t}$ is the change in the j^{th} deposit in the $(t-s)^{th}$ time period,

$_{e}u_{i,t}$ is white noise,

and

m is the total number of deposit categories,

$b_e = 0, 1, \ldots, N;\ N < \infty$ and is the lead or lag period of the operator L^{s_e}.

To understand why this model must be used in conjunction with the LGAM and LCAM models to test for a modified pool-of-funds behavior, consider the postulated flow of funds with the pool-of-funds approach. The pool-of-funds approach assumes that all funds flowing into the bank will go into a large pool. This model, the SFM, is designed to test if banks actually create such a pool. If such a pool is created, the pool-of-funds approach indicates that funds are allocated from the pool on a random basis. It is impossible to test for a pool-of-funds behavior when funds are allocated from the pool on a random manner. Therefore, assumptions must be made about how funds are to be allocated from the pool. To be consistent with the existing theories of asset portfolio adjustment, i.e., asset allocation and the theory implied by Cohen and Hammer (35) and Hester and Pierce (84) to rectify the deficiencies of the asset allocation approach, it is postulated that funds will flow from the pool in one of two ways. In the first way, it is assumed that the funds which came from long-term deposit categories will be taken from the pool and placed into assets with a long-term maturity. This assumption is in keeping with the asset allocation approach. In the second way, it is assumed that the pool, i.e., the bank's short-term assets, can be divided into permanent and transitory components. It is also assumed that the permanent component of the pool will eventually be placed into assets with a long-term maturity. This assumption allows for the "minimum amounts and stability" (35, p. 156) of a particular deposit category which the asset allocation approach does not consider.

The two assumptions about how funds are taken from the pool have a definite effect on bank behavior and therefore on the model to be tested. Consider the two assumptions on the outflow of funds from the pool in the order in which they are presented in the previous paragraph; the category assumption first and then the component assumption.

Dividing the inflow of funds into deposit categories shows that the summation of short-term and long-term deposits must equal total deposits. Therefore, placing the preceding statement in mathematical notation gives:

$$D_{j,t} = D_{v,t} + D_{z,t} \tag{5}$$

where:

$D_{j,t}$ is total deposits,

$D_{v,t}$ is short-term deposits,

$D_{z,t}$ is long-term deposits,

and

$j = 1, 2, \ldots, m,$

$v = 1, 2, \ldots, a,$ and

$z = 1, 2, \ldots, d.$

a, d, and m are the number of long-term, short-term, and total deposit categories on the bank's balance sheet, respectively. Substituting (5) into (4) and using the long term portion of that equation gives the formulation for the total adjustment process using a modified pool-of-funds behavior. It is:

$$_{e}A_{k,t} = \sum_{r_e = h_e}^{-h_e} w_{r_e} L^{r_e} \left[\sum_{s_e = b_e}^{-b_e} w_{s_e} L^{s_e} \left(\sum_{z=1}^{d} D_{z,t} \right) \right] + {}_{e}u_{k,t} \tag{6}$$

where:

$_{e}A_{k,t}$ is the change in the k^{th} long term asset for the e^{th} representation in the t^{th} time period,

w_{r_e} is the weight assigned to the change in the z^{th} deposit for the e^{th} representation in the $(t-s-r)^{th}$ time period,

L^{r_e} is the lag operator,

$\left[\sum_{s_e = b_e}^{-b_e} w_{s_e} L^{s_e} \left(\sum_{z=1}^{d} D_{z,t} \right) \right]$ is the change in the weighted z^{th} deposit or summation of deposit categories in time period (t-s) which went into the short-term asset pool,

e is a particular representation or design for each model,

${}_e u_{k,t}$ is white noise,

and

d is the number of long-term deposit categories which have an effect on ${}_e A_{k,t}$,

$h_e = 0, 1, \ldots, M$; $M < \infty$ and is the lead or lag period of the operator L^{r_e}.

Equation (6) states that the long-term k^{th} asset is a doubly lagged function of the long-term deposits. The first lag occurs when the deposits are converted into short-term assets, and the second lag occurs when portions of the short-term assets are converted into long-term assets.

Rearranging equation (6) to be:

$$ {}_e A_{k,t} = \sum_{r_e = h_e}^{-h_e} \sum_{s_e = b_e}^{-b_e} w_{r_e s_e} L^{r_e + s_e} \left(\sum_{z=1}^{d} D_{z,t} \right) + {}_e u_{k,t} \qquad (7) $$

shows that there are two differences between the LGAM and the total adjustment for long-term deposits using this modified pool-of-funds approach. The differences are the weights assigned to each lagged deposit and the length of the lag for each deposit.[3] The difference in the timing, i.e., the lag, is the primary consideration at this point.

There is only one set of data for each bank, therefore only one long-term model on a category by category basis can be estimated from the time series data for each bank. When a long term model on a category

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[3]The rearrangement of equation (6) into equation (7) is possible because of the additive and multiplicative properties of the phase and gain, respectively, within the spectral model.

by category basis is estimated and considered by itself, it will not be possible to tell whether the estimated model is the LGAM or equation (7). This is why the SFM must be compared to the SGAM to see if the bank actually creates a pool-of-funds. If the bank does, then the LGAM model can be expressed by equation (7). If the bank does not create a pool-of-funds then equation (2) is the best representation of the long-term adjustment process on a category by category basis.

The second way in which funds are assumed to be removed from the pool is on a component by component basis. It is obvious that for any deposit class j, total deposits, are comprised of the permanent and the transitory components of that deposit class. Stating this mathematically gives:

$$D_{j,t} = {}_{P}D_{j,t} + {}_{T}D_{j,t} \tag{8}$$

where:

$D_{j,t}$ is total deposits,

${}_{P}D_{j,t}$ is the permanent component of total deposits,

${}_{T}D_{j,t}$ is the transitory component of total deposits,

and

$j = 1, 2, \ldots, m$

m is the total number of deposit categories on the bank's balance sheet.

Substituting equation (8) into equation (4) shows that ${}_{e}A_{i,t}$ is a summation of the lagged permanent and transitory deposit components. ${}_{e}A_{i,t}$ is also a summation of the permanent and transitory components of the short term assets, i.e., ${}_{e}A_{i,t} = {}_{Pe}A_{i,t} + {}_{Te}A_{i,t}$. In this case ${}_{e}A_{i,t}$ is defined as before and:

${}_{Pe}A_{i,t}$ is the permanent component of the short term assets in period t, and

${}_{Te}A_{i,t}$ is the transitory component of the short term assets in period t.

Substituting equation (8) into (4) and considering the previous statement yields:

$$ {}_{Te}A_{i,t} + {}_{Pe}A_{i,t} = \sum_{s_e=b_e}^{-b_e} \Big(w_{s_e} L^{s_e} \sum_{j=1}^{m} {}_{Te}D_{j,t} + w_{s_e} L^{s_e} \sum_{j=1}^{m} {}_{Pe}D_{j,t}\Big) + {}_{e}u_{i,t} \tag{9}$$

From equation (9), it can be seen that:

$$ {}_{Te}A_{i,t} = \sum_{s_e=b_e}^{-b_e} w_{s_e} L^{s_e} \sum_{j=1}^{m} {}_{Te}D_{j,t} + {}_{e}u_{i,t} \tag{10}$$

and

$$ {}_{Pe}A_{i,t} = \sum_{s_e=b_e}^{-b_e} w_{s_e} L^{s_e} \sum_{j=1}^{m} {}_{Pe}D_{j,t} + {}_{e}u_{i,t} \tag{11}$$

Equation (10) and (11) are warranted because of the way in which the short-term asset portfolio is created in equation (4). Equation (4) states that the only contributor to the bank's short-term asset portfolio is the bank's deposit inflows.[4] While not strictly true, it is assumed that the inflows which are omitted will not significantly affect the

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[4]It should be pointed out that the formulation of the SFM model changes significantly if this assumption underlying equation (4) is changed. If this assumption is changed, equation (4) is written as:

$$ {}_{e}A_{i,t} = \sum_{s_e=b_e}^{-b_e} w_{s_e} L^{s_e} \Big(\sum_{j=1}^{m} D_{j,t} + O_t\Big) + {}_{e}u_{i,t} \tag{4A}$$

where:

short-term portfolio. Since deposits are the only contributor to the bank's short-term assets then the permanent deposit components must be permanent components of the short-term assets. There is no mechanism in the model which would cause the assets to deviate.

Equation (11) is the most important since it provides the information needed to show the outflow of funds from the pool on a component by component basis. In equation (11) funds are taken from the pool created in equation (4) and transferred to asset categories with longer maturities. The formulation for the removal of funds from the pool on a component basis is:

$$ {}_eA_{k,t} = \sum_{r_e=h_e}^{-h_e} w_{r_e} L^{r_e} \left(\sum_{i=1}^{n} P\,{}_eA_{i,t} \right) + {}_eu_{i,t} \tag{12} $$

Substituting (11) into (12) gives:

$$ {}_eA_{k,t} = \sum_{r_e=h_e}^{-h_e} w_{r_e} L^{r_e} \left(\sum_{s_e=b_e}^{-b_e} w_{s_e} L^{s_e} \sum_{j=1}^{m} P\,{}_eD_{j,t} \right) + {}_eu_{k,t} \tag{13} $$

Equation (13) indicates that the long-term assets are a time lagged function of the permanent components of the deposit categories. The

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O_t is the lagged funds inflow to short term assets from sources other than deposits, i.e., loan repayments, changes in the bank's capital, etc.,

and

${}_eA_{i,t}$, w_{s_e}, L^{s_e}, $D_{j,t}$ and ${}_eu_{i,t}$ are defined as in (4).

The formulation in equation (4A) means that equations (10) and (11) no longer hold. This in turn means that equation (13) must be changed to:

$$ {}_eA_{k,t} = \sum_{r_e=h_e}^{-h_e} w_{r_e} L^{r_e} \left(\sum_{i=1}^{n} P\,{}_eA_{i,t} \right) + {}_eu_{i,t} \tag{13A} $$

which is equation (12). The assumption is critical in determining the model which is to be tested.

first lag occurs when the deposits are placed into short-term, near cash assets, and the second is when the funds are taken from the short-term pool and transferred into assets with a longer maturity. Equation (13) postulates a flow from deposits to assets different from equation (6). The difference being that this equation assumes that funds flow out of the pool on a component basis.

Rearranging equation (13) yields:

$$ {}_{e}A_{k,t} = \sum_{r_e=h_e}^{-h_e} \sum_{s_e=b_e}^{-b_e} w_{r_e s_e} L^{r_e+s_e} \left(\sum_{j=1}^{m} Pe^{D_{j,t}} \right) + {}_{e}u_{k,t} \qquad (14) $$

Comparing equation (14) and the LCAM shows that there are two differences in the total adjustment for the permanent component of the deposits using this modified pool-of-funds approach. The differences are the weights assigned to each lagged deposit components and the length of the lag for each deposit component. As before, it is the lag that is the most important at this point.

In this case, as with the other method of outflow from the pool, there is only one set of data for each bank. Therefore, only one long-term adjustment model, on a component by component basis, can be estimated. When this long-term adjustment model is estimated and considered by itself, it will not be possible to determine whether the estimated model is the LCAM or equation (14). This is why the SFM must also be compared to the SCAM to see if the bank actually created a pool-of-funds. If the bank does create a pool-of-funds, then the LCAM model can be expressed by equation (14). If the bank does not create a pool-of-funds, then equation (16) is the best representation of the long-term adjustment process on a component by component basis.

Up to this point, the SFM has been compared to both the SGAM and the SCAM. If a bank does create a pool-of-funds it should be evidenced by the fact that the SFM has w's which are significantly different from 0 while the SGAM and SCAM does not. The only question remaining is, if the bank does create a pool-of-funds then does equation (7) or equation (14) best describe the long-run adjustment behavior from the pool, i.e., does the bank allocate funds from the pool on a category or component basis. An examination of the w's of the two models should indicate which behavior pattern the bank follows. The equation, i.e., model, which has w's significantly different from 0 will be the model which best describes the bank's behavior. If the bank does create a pool-of-funds and neither equation (7) or (14) have w's significantly different from 0, then this would give evidence of a pure pool-of-funds behavior.

A Short Term Component Allocation Model (SCAM). The short term component allocation model is designed to test hypothesis 4 in the previous section. This model is a test of bank behavior first implied by Cohen and Hammer (35) and later explicitly stated, but not actually tested, by Hester and Pierce (84). The model will assume that a bank can determine the permanent and transitory components of any deposit inflow. It will also assume that the bank adjusts its asset portfolio in response to the permanent or transitory nature of the deposit inflows. It is postulated that the bank will allocate the permanent components of its deposits, regardless of the short-term or long-term nature of the deposit category, to the long-term assets and the transitory components to the short-term assets. This model will test the transitory component to short-term asset assumption.

The formulation of the model is:

$$ {}_{e}A_{i,t} = \sum_{r_e=b_e}^{-b_e} w_{r_e} L^{r_e} \left(\sum_{j=1}^{m} {}_{Te}D_{j,t} \right) + {}_{e}u_{i,t} \qquad (15) $$

where:

${}_{e}A_{i,t}$ is the change in the i^{th} short term asset for the e^{th} representation in the $(t-r)^{th}$ time period,

w_{r_e} is the weight assigned to the transitory part of the change in the j^{th} deposit for the e^{th} representation in the $(t-r)^{th}$ time period,

L^{r_e} is the lag operator,

${}_{Te}D_{j,t}$ is the transitory component of the change in the j^{th} deposit in the $(t-r)^{th}$ time period,

e is a particular representation or design for each model,

${}_{e}u_{i,t}$ is white noise,

and

m is the total number of deposits which have an effect on ${}_{e}A_{k,t}$,

$b_e = 0, 1, \ldots, M$; $M < \infty$ and is the lead or lag period of the operator L^{r_e}.

This model, along with the LCAM, is designed to eliminate the shortcomings of the asset allocation theory as presented by Cohen and Hammer (34) and Cohen and Hammer (35).

A Long Term Component Allocation Model (LCAM). This model is designed to test hypothesis 5 from the previous section. Like the SCAM, this model will assume that a bank can determine the permanent and transitory components of any deposit inflow. It will also assume that the bank adjusts its asset portfolio in response to the permanent or transitory nature of the deposit inflows. This model will test the permanent component to long-term asset assumption.

The formulation of the model is:

$$ {}_{e}A_{k,t} = \sum_{s_e=h_e}^{-h_e} w_{s_e} L^{s_e} \sum_{j=1}^{m} Pe^{D}_{j,t} + {}_{e}u_{k,t} \tag{16} $$

where:

${}_{e}A_{k,t}$ is the change in the k^{th} long term asset for the e^{th} presentation in the $(t-s)^{th}$ time period,

w_{s_e} is the weight assigned to the permanent component for the change in the j^{th} deposit for the e^{th} representation in the $(t-r)^{th}$ time period,

L^{s_e} is the lag operator,

$Pe^{D}_{j,t}$ is the permanent component of the change in the j^{th} deposit in the $(t-s)^{th}$ time period,

e is a particular representation or design for each model,

${}_{e}u_{k,t}$ is white noise,

and

m is the total number of deposits which have an effect on ${}_{e}A_{k,t}$,

$h_e = 0, 1, \ldots, N; N < \infty$ and is the lead or lag period of the operator L^{s_e}.

This model, like the SCAM, is designed to eliminate the shortcomings of the asset allocation theory as presented by Cohen and Hammer (34) and Cohen and Hammer (35).

Optimization Models

This research will use two optimization models to test hypotheses 4 and 5. The two models assume a specific objective on the part of bank management, i.e., bank management adjusts its asset portfolio in an attempt to reach a desired objective.

A Linear Optimization Model (LOM). The model assumes that the objective of bank management is to maximize the bank's profits. The bank is adjusting its asset portfolio in an attempt to maximize profits is subject to various liquidity, legal and institutional constraints. The model includes the most accepted, i.e., most common and familiar, constraints found in the financial literature. This model, however, does not explicitly include one of the most important financial variables, i.e., risk.

The formulation of the model is:

$$\text{Maximize} \quad P = c_1 x_1 + \ldots + c_N x_N \text{ [5]} \tag{17}$$

subject to:

$$.005A_1 + .04A_2 + .04A_3 + .06A_4 + .10A_5 + .65L_1 + .04L_2 + .095L_3 \leq R_k K \tag{18}$$

$$c + .995A_1 + .96A_2 + L_1 \geq D_L \tag{19}$$

$$c + .995A_1 + .96A_2 + .90A_3 + L_2 > D_L \tag{20}$$

$$c + .995A_1 + .96A_2 + .90A_3 + .85A_4 + L_3 \geq D_L \tag{21}$$

$$x_3 \geq r_1 D_d + r_2 D_s \tag{22}$$

$$x_6 + x_8 + x_{10} + x_{12} \geq R_{PA} (D_F + D_{st}) \tag{23}$$

$$x_5 + x_7 + x_9 + x_{11} + x_{13} + x_{14} + x_{15} + x_{16} \leq R_r K \tag{24}$$

$$x_2 \geq \text{Required Currency Holdings} \tag{25}$$

$$x_4 \geq \text{Required Balances} \tag{26}$$

[5]This model follows closely the notation and model in Beazer (8).

$$x_{17} = \text{The Amount Required} \quad (27)$$

$$x_1 = \text{The Amount Required} \quad (28)$$

$$\sum_{i=1}^{g} x_i = 1 \quad (29)$$

and

$$x \geq 0 \text{ for all } i = 1, 2, \ldots, g \quad (30)$$

where:

x represents the g asset categories of the bank defined in Table I. Each asset category is expressed as a percent of total assets.

e, A_1, A_2, A_3, and A_4 are the liquidity classes of the bank's assets defined in Table I.

L_1, L_2, and L_3 are capital adequacy variables which will cause the liquidity provided from the assets to be greater than or equal to the liquidity needed from the liabilities.[6]

D_L is the liquidity needed as a function of the bank's liabilities,[7]

K is the bank's actual capital,

R_k is the ratio of the bank's required to actual capital,

r_1 is the demand deposit reserve requirement,

r_2 is the savings deposit reserve requirement,

D_d is the bank's demand deposits,

D_s is the bank's savings deposits,

R_{PA} is the bank's safety factor for covering its pledged assets and is greater than one,

D_F are the United States government deposits,

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[6]For a detailed definition of L, see Beazer (8), pages 56 through 61.

[7]D_L = .47 (demand deposits) + .36 (time deposits) + (deposits of banks and government) + (borrowings).

TABLE I

ASSETS ACCORDING TO LIQUIDITY CLASS

Liquidity Class	Variable	Asset	Rate of Return
C	X_1	Cash in process of collection	$c_1 = 0$
	X_2	Currency and coin	$c_2 = 0$
	X_3	Reserves with Federal Reserve	$c_3 = 0$
	X_4	Balances with banks	$c_4 = 0$
A_1	X_5	Loans to banks (fed. funds)	$c_5 > 0$
	X_6	Bills, certificates, govts. under one year	$c_6 > 0$
	X_7	Loans to brokers	$c_7 > 0$
A_2	X_8	Governments, 1-5 years	$c_8 > 0$
	X_9	Loans to finance companies	$c_9 > 0$
A_3	X_{10}	Governments 5-10 years	$c_{10} > 0$
	X_{11}	Loans for purchase of securities	$c_{11} > 0$
A_4	X_{12}	Governments over 10 years	$c_{12} > 0$
A_5	X_{13}	Real estate loans	$c_{13} > 0$
	X_{14}	Municipals and other securities	$c_{14} > 0$
	X_{15}	Agricultural, commercial, and individual loans	$c_{15} > 0$
	X_{16}	Consumer loans	$c_{16} > 0$
A_6	X_{17}	Other assets	$c_{17} > 0$
L_1	X_{18}	Capital adequacy vectors	$c_{18} = 0$
L_2	X_{19}	Capital adequacy vectors	$c_{19} = 0$
L_3	X_{20}	Capital adequacy vectors	$c_{20} = 0$

Source: Beazer (8).

D_{st} are state government deposits, and

R_r is the risk asset to capital ratio.

Equation (17) is the bank's profit function which is to be maximized. Equations (18) through (21) are capital adequacy constraints placed on a bank by the comptroller of the currency. The coefficients in equations (18) and (21) are those actually used by federal bank examiners. Equation (22) represents the bank's required reserves. Equation (23) makes sure the bank has enough of the proper securities pledged to cover its government deposits. A bank must hold capital equal to a certain percentage of its risk assets. Equation (24) constrains the bank to meet this requirement. Equation (25) causes the bank to hold enough currency and coin to cover its day to day transactions. Equation (26) forces the bank to cover the balances it must keep with other banks. It is assumed that the balances actually held are those actually required. It does not make sense to hold funds in nonearning assets if the bank does not have to. Equations (27) and (28) are balancing items. Equation (29) is the balance sheet constraint.

A Mean-Variance Optimization Model (MVOM). This model, like the LOM, is designed to test the management science theory of bank behavior. More specifically, it is designed to test hypothesis 5. The model assumes that the objective of bank management is to minimize the bank's risk for a given level of return or maximize return for a given risk class. The difference in this model and the LOM is the explicit incorporation of risk into the model.

The formulation of the model is:

$$\text{Minimize Portfolio Variance} = \sum_{j=1}^{N} \sum_{k=1}^{N} w_j \, w_k \, \sigma_{jk} \qquad (31)$$

subject to:

$$\sum_{j=1}^{N} w_j - 1 = 0 \qquad (32)$$

and

$$\sum_{j=1}^{N} w_j \, E(r_j) - E_1 = 0 \qquad (33)$$

where:

σ_{jk} represents the variance-covariance matrix of the bank's asset portfolio and is given such that $\sigma_{jk} = \sigma_{kj}$.

w_j is the weight assigned to the j^{th} asset of the portfolio. It is equal to the dollar value of the j^{th} asset divided by the dollar value of the total asset portfolio.

$E(r_j)$ is the actual expected return on the j^{th} asset, and

E_1 is the desired expected return.

Equation (31) is the objective function to be minimized. It provides an explicit measure of the bank's risk considerations and indicates that the bank establishes an acceptable rate of return and then minimizes the risk for that rate of return. Equation (32) is a balance sheet constraint. Equation (33) insures that only portfolios with the same expected return are considered.

The model postulates that the bank makes its portfolio decisions in a mean variance world. It also presumes that cash is the riskless rate with a return of zero. Cash along with the other assets will define the efficient frontier for the bank, i.e., those asset portfolios with the lowest risk for a given level of return.

CHAPTER IV

RESEARCH METHODOLOGY

This section of the study identifies the procedures to be used in testing the models stated in the previous section. It is followed by two separate sections which will state the tests to be used for comparing the predicted results with the actual results and the data sources, respectively.

The seven models to be tested are again divided into heuristic and optimization groupings. The heuristic models, i.e., LGAM, SGAM, SFM, SCAM and LCAM are to be determined using spectral analysis and Hannan's inefficient method. The optimization models, i.e., LOM and MVOM, will use linear and quadratic programming, respectively.

Techniques to Test the Heuristic Models

The test of the heuristic models is a three step process. First, spectral analysis will be used for two purposes. It will be used to determine the length of the lead and lag structure for the heuristic models. Then it will be used to filter the change in the deposit inflows to obtain the permanent and transitory components for the deposit categories. Second, Hannan's inefficient method will be used to generate specific coefficients for each model and to test the statistical significance of those coefficients. Third, the model's coefficients will be used to generate predicted values for the changes in the asset categories in subsequent periods. The predicted asset portfolio will then be compared to the actual asset portfolio held by the bank.

The period for empirical testing is from June 13, 1973 to October 27, 1976. A 151 week period from June 13, 1973 to April 28, 1976 was used to generate the coefficients for the heuristic models. These coefficients were then used to generate the predicted asset portfolios for 27 weeks, at three week intervals. This period is from May 12, 1976 through October 27, 1976. Over the 27 week period, nine predicted portfolios were generated.

Spectral analysis provides three basic statistics in comparing one time series against another. The first is known as the gain. The gain gives, at each frequency, the amount that one series must be multiplied by to approximate the other time series. The gain is similar to a regression coefficient at each frequency where one time series is the dependent variable and one the independent variable. The second is known as the phase. The phase tells the fraction of a cycle that one series lags behind another. The third is known as the coherence squared. The coherence squared between two time series is like a correlation coefficient and will always be between 0 and 1.

The two statistics which this study will be most interested are the gain and the phase. These two statistics can be plotted for almost any theoretical relationship between two time series, i.e., a one period lag model between two time series will have a gain and phase diagram which is unique to that model. These plots are known as BODE plots or the gain and phase diagrams. Since BODE plots can be established for almost any hypothesized relationship between two time series,[1] it is possible to use these plots to define unknown relationships between two time series. Two time series, e.g., demand deposit inflows and treasury securities, could be compared such that a gain and phase diagram for the two series was obtained. The BODE plots for the unknown relationship could then be compared to the BODE plots for the known relationships until the unknown BODE plots matched a pair of known plots (53). The matching of the unknown with the known BODE plots would define the unknown relationship between the two time series. Once spectral analysis determines an approximate lag between the two series, Hannan's inefficient method will be used to estimate the exact coefficients of the model. The LGAM and SGAM will be determined in exactly this manner.

The SCAM and LCAM will be tested in the same way, i.e., using known BODE plots to define an unknown relationship. The difference in testing these models relative to the previous two is with regard to the time series being tested. The SGAM and LGAM models postulate that all of a deposit category's funds are allocated to the appropriate, i.e., short-term or long-term, asset categories. The LCAM and SCAM postulate that the deposit funds are first divided into permanent and transitory components and then allocated to the appropriate, i.e., long-term or short-term, respectively, asset categories. Therefore, to test the LCAM and SCAM their permanent and transitory components must be determined.

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[1]This is due to the multiplicative and additive properties of the gains and phases of two time series, respectively, which have been multiplied together.

Spectral analysis again provides the tool for separating a time series into its permanent and transitory components. Spectral analysis, through the fourier transform, transforms a time series into the various frequency components which make up the series. By their definitions, permanent and transitory components represent funds which are with the bank all the time and funds which are transient in nature, respectively. Funds represented by high frequencies of the frequency spectrum would be those funds which are transient in nature. Funds represented by low frequencies of the frequency spectrum would be those funds which are permanent with the bank. The term used in spectral analysis for separating the time series by frequency is demodulation. Spectral analysis will demodulate the deposit categories into their permanent and transitory categories. With the LCAM and SCAM, spectral analysis will be used as a two-step process to define the models. First, spectral analysis will divide the deposit categories into their permanent and transitory components. Second, the permanent and transitory components will be used as a basis to define the length of the lag for each model.

Once all five models, i.e., LGAM, SGAM, SFM, SCAM and LCAM, have been defined, Hannan's inefficient method will be used to define the specific coefficients for each lagged variable. The coefficients should provide two things. First, the significant coefficients will be used to generate the predicted asset portfolios. Second, the significant coefficients will indicate the lead-lag structure for particular liability and asset categories. This latter function will also show if there is any significant relationship between a particular asset and liability category.

Techniques to Test the Optimization Models

The tools chosen to test the LOM and MVOM are linear programming and quadratic programming, respectively. As with the heuristic models, linear and quadratic programming will be used to generate predicted values for the bank's asset portfolio. These predicted values will then be compared to the actual portfolios held by the banks to determine if either is the best model of bank behavior.

Procedures to Test the Predictive Ability of the Models

One test will be used to determine which of the models has the best predictive ability. This test of the models' predictive ability will be the root mean square error (RMSE). This test will be used for all seven models. It will provide the final answer to the question, which model is the best predictor of current bank behavior. The RMSE for the ℓ^{th} asset category is:

$$\mathrm{RMSE}_{\ell} = \left[\frac{\sum_{j=1}^{n} ({}_{p}Y_{\ell j} - {}_{a}Y_{\ell j})^{2}}{N} \right]^{1/2} \tag{34}$$

where:

${}_{p}Y_{\ell j}$ is the predicted value of the ℓ^{th} asset,

${}_{a}Y_{\ell j}$ is the actual value of the ℓ^{th} asset,

N is the number of observations,

M is the number of asset categories of the bank,

and

$\ell = 1, 2, \ldots, M$

$j = 1, 2, \ldots, N.$

No standardized tests exist to evaluate this statistic, therefore, comparison with other models is the only way to determine the worth of the predicted values.

Data

The data for both the heuristic and optimization models for all four banks comes from six sources. The six sources are:

1. A weekly report of deposits and related data submitted by each bank to the eleventh Federal Reserve District.
2. A weekly report of condition for the four largest banks in the Dallas area, distributed by the eleventh Federal Reserve District.
3. The annual report of condition for the four banks, submitted by the banks to the Federal Reserve Board.
4. The annual report of income for the four banks, submitted by the banks to the Federal Reserve Board.
5. The Federal Reserve Bulletin.
6. The Monthly Consumer Loan Interest Rate Survey, put out by the Division of Administrative Services of the Board of Governors of the Federal Reserve System.

The data from the first four sources is used to estimate the beta coefficients in the heuristic models. The data from sources five and six is used in the optimization models as surrogates for some of the yields on investments made by the bank.

The weekly data on the four asset categories studied, i.e., coin and currency, treasury securities, other securities and total loans, as well as the three liability categories studied, i.e., net demand deposits, savings deposits and other time deposits, comes from sources one and two. Sources three and four were used to confirm or check the data provided by sources one and two.

CHAPTER V

RESULTS OF EMPIRICAL TESTS

The results in this chapter are presented in two sections. The first section presents the interpretations of the coefficients and coefficient patterns for the heuristic models. The results in this section are presented by models and related back to the five hypotheses for the heuristic models. The second section presents the root mean square errors for the heuristic and optimization models. The root mean square errors for the heuristic models are presented first, followed by the root mean square errors for the linear programming and quadratic programming models, respectively. The listings for the asset and liability category designations are shown in Figure 1.

Interpretation of the Coefficients and Coefficient Patterns of the Heuristic Models

The results of the five heuristic stochastic models are presented in the following order: LGAM, SCAM, SFM, SCAM and LCAM. The results of each model for all four banks will be presented at the same time such that a comparison may be made, by model, between banks.

Results of the LGAM Model

Two asset and two liability categories were chosen as being long term asset and liability categories. The two asset categories are total loans and other securities held by the bank, i.e., these are securities

CC = coin and currency

TS = treasury securities

OS = securities other than treasury securities

TL = total loans

NDD = net demand deposits

SAVD = savings deposits

OTD = time deposits other than savings deposits

TNS = NDD + SAVD

TNT = NDD + OTD

TST = SAVD + OTD

TNST = NDD + SAVD + OTD

Any designation which is followed with an S, i.e., CCS, NDDS, TNTS, etc., represents the short-term component of the filtered asset and liability categories.

Any designation which is followed with an L, i.e., TSL, SAVDL, TSTL, etc., represents the long-term component of the filtered asset and liability categories.

Figure 1. Listing of Asset and Liability Category Designations

other than treasury securities. The two liability categories are other time deposits, i.e., time deposits other than savings deposits, and total time deposits, i.e., a combination of both savings and other time deposits. The two asset and liability categories provide four combinations of the asset and liability categories which are tests of the LGAM model for each bank. The four combinations for each bank and their coefficients are presented in Tables II through V. Table II presents the combinations of the asset and liability categories which represent the LGAM model for bank 1. Table III is for bank 2. Table IV is for bank 3. Finally, Table V is for bank 4.

Other Time Deposits on Total Loans. As Tables II-V indicate, the coefficients of the OTD on TL representation of the LGAM model are bank dependent, i.e., the pattern of significant coefficients for each bank does not exhibit a uniformity throughout the four banks. For banks 1, 2, and 4, however, all of the significant coefficients in this representation of the model are positive. This indicates that an increase in any OTD category in a period with a significant coefficient will cause an increase in the TL category. The only other relationship common to banks 1, 2, and 4, is that the total loans of each bank are affected by both lagged and leading amounts of other time deposits. The significance of the lagged coefficients was expected. Since a first difference was taken in the data prior to applying Hannan's inefficient method, the change in the OTD category provides a source of funds for which a use is found some periods later in the change in total loans. The significance of the lead coefficients was not anticipated. Their significance is most probably caused by an active liability management on the part of banks 1, 2, and 4. Each of the banks in time period t anticipates its future

TABLE II

COEFFICIENTS FOR THE LGAM FOR BANK 1

Time Period	OTDB1 on TLB1	OTDB1 on OSB1	TSTB1 on TLB1	TSTB1 on OSB1
	Liability on Asset Category			
11	.118*	-.09 *	.012	-.065*
10	.049	-.052*	.07 *	-.065*
9	.025	0	.019	-.025*
8	.142*	.007*	.11 *	.05 *
7	.08 *	-.23 *	.072*	-.28 *
6	.149*	-.105*	.114*	.01 *
5	.137*	-.02 *	.144*	-.01 *
4	-.05	-.045*	-.025	-.03 *
3	.137*	-.17 *	.1 *	-.18 *
2	.19 *	-.28 *	.11 *	-.25 *
1	.075*	-.23 *	.105*	-.22 *
0	.001	-.08 *	0	-.125*
-1	.18 *	-.29 *	.115*	-.225*
-2	.05 *	-.065*	-.008	-.11 *
-3	.075*	-.09 *	.065*	-.07 *
-4	.24 *	-.22 *	.18 *	-.15 *
-5	.02	-.09 *	.04	-.11 *
-6	.147*	-.26 *	.117*	-.205*
-7	.07 *	-.11 *	.038	-.065*
-8	.02	.04 *	.059*	.01 *
-9	.051*	-.007*	.051*	.05 *
-10	.051*	.01 *	.05	.01 *
-11	-.001	-.19 *	.025	-.155*
-12	.02	-.15 *	.01	-.125*

*Indicates coefficients that are significant at the 5% level.

TABLE III

COEFFICIENTS FOR THE LGAM FOR BANK 2

	Liability on Asset Category			
Time Period	OTDB2 on TCB2	OTDB2 on OSB2	TSTB2 on TLB2	TSTB2 on OSB2
11	.06 *	0	.035*	-.01 *
10	.07 *	-.05 *	.05 *	-.06 *
9	.035*	.038*	.02 *	.028*
8	.197*	.088*	.175*	.079*
7	.21 *	-.001	.19 *	-.007
6	.22 *	-.001	.19 *	-.007
5	.225*	.055*	.225*	.048*
4	.17 *	.062*	.16 *	.06 *
3	.16 *	.02 *	.14 *	.02 *
2	.1 *	-.01	.07 *	-.012*
1	.06 *	.075*	.05 *	.03 *
0	.175*	.03 *	.15 *	-.044*
-1	.17 *	-.055*	.15 *	-.053*
-2	.05 *	.07 *	.03 *	.07 *
-3	.08 *	.059*	.06 *	.058*
-4	.14 *	.09 *	.13 *	.087*
-5	.36 *	.042*	.34 *	.04 *
-6	.098*	.01	.075*	.01
-7	.16 *	.1 *	.145*	.097*
-8	.02	.093*	-.01	.088*
-9	-.02	.042*	-.04 *	.038*
-10	.05 *	.015*	.048*	.01
-11	.16 *	.028*	.15 *	.019*
-12	-.03 *	.047*	-.057*	.039*

*Indicates coefficients that are significant at the 5% level.

TABLE IV

COEFFICIENTS FOR THE LGAM FOR BANK 3

Time Period	Liability on Asset Category: OTDB3 on TLB3	OTDB3 on OSB3	TSTB3 on TLB3	TSTB3 on OSB3
11	0	-.001	-.002	-.001
10	.007	.022*	.008	.022 *
9	-.0025	.005	-.0025	.005
8	.008	.03 *	.009	.03 *
7	0	-.018*	-.0001	-.015 *
6	.015	.01 *	.016	.005
5	.032	-.001	.033	-.002
4	.04	-.001	.009	-.002
3	.017	.01 *	.017	.01 *
2	.008	-.001	.007	-.002
1	.005	.01 *	.006	.012 *
0	.024	.118*	.024	.12 *
-1	.011	-.009*	.013	-.002
-2	.0075	.008*	.0075	.002
-3	.01	.014*	.01	.0012*
-4	-.0001	-.008*	.002	-.002
-5	.0148	.07 *	.012	.07 *
-6	.017	.092*	.018	.99 *
-7	.016	-.075*	.018	-.07 *
-8	.0355	.008*	.037	.01 *
-9	.029	-.022*	.033	-.021 *
-10	.012	-.008*	.014	-.01 *
-11	.022	0	.023	0
-12	.005	0	.008	0

*Indicates coefficients that are significant at the 5% level.

TABLE V

COEFFICIENTS FOR THE LGAM FOR BANK 4

Time Period	OTDB4 on TLB4	OTDB4 on OSB4	TSTB4 on TLB4	TSTB4 on OSB4
	Liability on Asset Category			
11	.115*	.0375*	.09 *	.028 *
10	.05	.031	.028	.021
9	.067*	.028	.041	.019
8	.139*	.015	.11 *	.005
7	.13 *	.014	.1 *	.0045
6	.115*	.038 *	.09 *	.029 *
5	.163*	.039 *	.139*	.029 *
4	.179*	.048 *	.152*	.039 *
3	.048	.046 *	.02	.0375*
2	.06	.039 *	.032	.029 *
1	.067*	.0475*	.04	.0375*
0	.095*	.024	.07 *	.015
-1	.115*	.0575*	.088*	.046 *
-2	.121*	.048 *	.1 *	.039 *
-3	.07 *	.035 *	.048	.026 *
-4	.088*	.031	.059*	.021
-5	.119*	.035 *	.098*	.026 *
-6	.09 *	.031	.062*	.024
-7	.058	.034 *	.035	.025 *
-8	.139*	.062 *	.118*	.055 *
-9	.063*	.038 *	.038	.03 *
-10	.12 *	.041 *	.098*	.031 *
-11	.09 *	.033 *	.07 *	.024
-12	.12 *	.028	.098*	.019

*Indicates coefficients that are significant at the 5% level.

cash flows for t+N periods. The cashflows it anticipates in the future periods obviously affect the amount of funds which each bank attempts to raise and use in period t.

Bank 3 does stand alone in that all of the coefficients for the OTD on the TL representation of the LGAM model are insignificant. This indicates that the funds provided by the OTD category do not significantly affect the funds used in the TL category for bank 3.

Other Time Deposits on Other Securities. This representation of the LGAM model is also bank dependent. In this case all four banks show significant lead and lag coefficients.

The significant lag coefficients were anticipated. The significant lead coefficients were not anticipated. The explanation of the significant lag coefficients is the same as before, i.e., a source of funds which has found a use. The explanation of the significant lead coefficients is once again an active liability management policy where each bank considers anticipated cash inflows when determining the funds to be used in a particular period.

Banks 2, 3, and 4 all show a majority of positive coefficients which indicate that OTD and OS move in the same direction for these banks. Bank 1 differs from banks 2, 3, and 4 in that 19 of 21 significant coefficients are negative. This indicates that other time deposits and other securities move in opposite directions. A possible explanation is that bank 1 was making a concerted effort to increase total loans over the time period studied. This bank may have chosen to increase its funds available for loans by increasing some liabilities, i.e., other time deposits, and decreasing some assets, i.e., other securities.

Total Savings and Other Time Deposits on Total Loans. This design of the LGAM model finds results very similar to the previous two. Banks 1, 2, and 4 have both significant lead and lag relationships. The coefficients for bank 3 are all insignificant. As with previous representations of this model, significant lag relationships were expected; significant lead relationships were not. The explanations for the significant lead and lag coefficients are the same as those used for OTD and TL. Of the 51 significant coefficients for banks 1, 2, and 4, only two of the coefficients for bank 2 are negative. Forty-nine of the 51 coefficients are positive. For banks 1, 2, and 4, total savings and other time deposits move in the same direction as total loans. This result and the insignificant coefficients for bank 3 were expected. The OTD component of the TST series dominates the savings deposits in the TST series. Therefore, it is not surprising to find results from this design of the model which are similar to those found in the OTD on TL representation of the model.

Total Savings and Other Time Deposits on Other Securities. This depiction of the LGAM model yields significant lead and lag coefficients for all four banks. The explanations for these coefficients are the same as those for previous designs of the model. For banks 2, 3, and 4, the vast majority of their significant coefficients are positive. This indicates that as total savings and other time deposits increase for these three banks then so does their other securities. As with the OTD on OS representation, bank 1 for this design of the model has a majority of significant coefficients which are negative, i.e., 18 of the 20 coefficients. The explanation for these negative coefficients could be the same as that given the OTD on OS representation of the model. This explanation is further reinforced by the fact that the OTD component of TST dominates the savings deposit component of the series. Because of this domination, it is not surprising that the results from this design of the model are similar to those of the OTD on OS design.

Results of the SGAM Model

For this model two asset and three liability categories were chosen as being short-term asset and liability categories. The asset categories are coin and currency and treasury securities. The liability categories are net demand deposits, savings deposits and a summation of net demand deposits and savings deposits called total net demand and savings deposits. The two asset and three liability categories provide for six different designs of the SGAM model. The six designs and their coefficients are presented in Table VI through IX. Tables VI through IX each present all six designs of the SGAM model for banks 1, 2, 3, and 4, respectively.

Net Demand Deposits on Coin and Currency. This description of the SGAM indicates significant lead and lag coefficients for all four banks. The significant lag coefficients were anticipated and indicate that funds used in period t have come from sources in periods t-N. The significant lead coefficients were not predicted. They indicate that bank assets held in period t depend upon anticipated deposit inflows in periods t+N.

As can be seen for the NDD on CC representation of the SGAM model almost all of the coefficients for the 12 lead and lag periods are

TABLE VI

COEFFICIENTS FOR THE SGAM FOR BANK 1

	Liability on Asset Category					
Time Period	NDDB1 on CCB1 x 10^{-2}	SAVDB1 on CCB1	TNSB1 on CCB1 x 10^{-2}	NDDB1 on TSB1	SAVDB1 on TSB1	TNSB1 on TSB1
11	-.35 *	-.0071	-.18 *	.068*	.05 *	.045*
10	-.2 *	-.02 *	-.09 *	.065*	.15 *	.049*
9	-.15	-.014	-.04 *	.03 *	.18 *	.019*
8	-.4 *	-.0163*	-.27 *	-.05 *	.5 *	-.05 *
7	-.38 *	.0124	-.18 *	-.06 *	-.17 *	-.078*
6	-.355*	.01	-.18 *	.015*	-.82 *	-.02 *
5	-.35 *	-.005	-.21 *	.055*	-.12 *	.033*
4	-.21 *	-.006	-.09 *	.059*	.09 *	.04 *
3	-.475*	0	-.3 *	.059*	.19 *	.04 *
2	-.65 *	-.006	-.49 *	.083*	.2 *	.063*
1	-.56 *	-.009	-.38 *	.063*	.19 *	.044*
0	-.44 *	-.02 *	-.31 *	.042*	.19 *	.028*
-1	-.70 *	-.015	-.56 *	.087*	.1 *	.074*
-2	-.45 *	0	-.29 *	.058*	.19 *	.042*
-3	-.1	-.005	.07 *	.03 *	.19 *	.015*
-4	-.2 *	-.0034	-.04 *	.05 *	.08 *	.024*
-5	-.23 *	0	-.1 *	.07 *	.1 *	.053*
-6	-.3 *	-.0075	-.17 *	.055*	-.025*	.039*
-7	-.31 *	-.0085	-.17 *	.039*	-.04 *	.019*
-8	-.3 *	.0123	-.09 *	.02 *	.03 *	.002*
-9	-.38 *	-.006	-.23 *	.019*	1.3 *	0
-10	-.29 *	.0124	-.13 *	.024*	1.3 *	.015*
-11	-.57 *	-.013	-.44 *	.023*	.09 *	.009*
-12	-.18 *	.0075	-.0015*	.087*	.03 *	.063*

*Indicates coefficients that are significant at the 5% level.

TABLE VII

COEFFICIENTS FOR THE SGAM FOR BANK 2

Time Period	NDDB2 on CCB2 x 10^{-2}	SAVDB2 on CCB2	TNSB2 on CCB2 x 10^{-2}	NDDB2 on TSB2	SAVDB2 on TSB2	TNSB2 on TSB2
	Liability on Asset Category					
11	.54*	.02 *	.21 *	.618*	1.2 *	.178*
10	.55*	.1 *	.25 *	.609*	-2.1 *	.162*
9	.57*	.12 *	.27 *	.598*	.5 *	.155*
8	.54*	-.225*	.23 *	.628*	2.35*	.183*
7	.52*	.05 *	.22 *	.66 *	1.75*	.22 *
6	.48*	.08 *	.175*	.647*	-1.55*	.208*
5	.48*	.025*	.175*	.657*	-1.75*	.219*
4	.44*	-.09 *	.14 *	.653*	.25*	.214*
3	.54*	.07 *	.23 *	.639*	1.73*	.2 *
2	.15*	.05 *	-.12 *	.682*	2.34*	.25 *
1	.38*	.08 *	.1 *	.671*	1.2 *	.239*
0	.7 *	-.055*	.4 *	.627*	.48*	.195*
-1	.3 *	-.225*	.02	.61 *	-.1 *	.179*
-2	.41*	-.335*	.15 *	.6 *	-1.7 *	.171*
-3	.54*	-.165*	.27 *	.59 *	.65*	.159*
-4	.6 *	.11 *	.31 *	.598*	-1.3 *	.162*
-5	.22*	-.125*	-.07 *	.583*	1.48*	.155*
-6	.49*	.08 *	.2 *	.57 *	2 *	.138*
-7	.24*	.02 *	-.05 *	.592*	.2 *	.159*
-8	.25*	-.045*	-.05 *	.579*	-.8 *	.142*
-9	.19*	.02 *	-.11 *	.52 *	.49*	.088*
-10	-.01	.07 *	-.31 *	.583*	1 *	.123*
-11	.48*	.06 *	.17 *	.549*	-.4 *	.108*
-12	.3 *	-.105*	-.02	.578*	-1.3 *	.139*

*Indicates coefficients that are significant at the 5% level.

TABLE VIII

COEFFICIENTS FOR THE SGAM FOR BANK 3

	Liability on Asset Category					
Time Period	NDDB3 on CCB3 x 10^{-2}	SAVDB3 on CCB3	TNSB3 on CCB3 x 10^{-2}	NDDB3 on CCB3	SAVDB3 on CCB3	TNSB3 on CCB3
11	-1.2 *	-.006*	-.005 *	-.138*	-.1 *	-.09 *
10	-1.22*	.005*	-.0005*	-.072*	-.51*	-.032*
9	-.32*	.01 *	.0038*	-.044*	.1 *	.002
8	-.6 *	-.042*	-.0001	-.055	-.03*	.04 *
7	-1.47*	-.01 *	-.0082*	-.11 *	.01*	-.06 *
6	-.75*	-.006*	-.001	-.085*	-.2 *	-.042*
5	-.28*	-.006*	.004 *	-.08 *	-.18*	-.038*
4	-.2 *	.01 *	-.0132*	-.098*	-.14*	-.052*
3	-1.47*	-.01 *	-.0091*	-.04 *	-.46*	-.01
2	-1.22*	-.01 *	-.008 *	-.118*	-.41*	-.08 *
1	-.9 *	-.18 *	-.0007*	-.095*	-.36*	-.06 *
0	-1.41*	-.07 *	-.018 *	-.152*	-.11*	-.11 *
-1	-2.22*	-.06 *	-.0175*	-.165*	.04*	-.115*
-2	-2.1 *	-.008*	-.016 *	-.172*	-.29*	-.125*
-3	-2.1 *	-.01 *	-.0147*	-.172*	-.16*	-.13 *
-4	-2.2 *	-.001*	-.015 *	-.165*	-.05*	-.12 *
-5	-1.46*	-.032*	-.0082*	-.125*	-.19*	-.08 *
-6	-1.8 *	.003*	-.0117*	-.073*	-.12*	-.025*
-7	-1.8 *	.001*	-.0117*	-.102*	-.05*	-.055*
-8	-1.7 *	.003*	-.011 *	-.1 *	.01*	-.051*
-9	-.8 *	-.06 *	-.002	-.08 *	-.16*	-.03 *
-10	-1.8 *	.013*	-.011 *	-.097*	-.31*	-.051*
-11	-1.26*	.048*	-.005 *	-.122*	-.01*	-.072*
-12	-2.07*	-.04 *	-.014 *	-.156*	.15*	-.11 *

*Indicates coefficients that are significant at the 5% level.

TABLE IX

COEFFICIENTS FOR THE SGAM FOR BANK 4

	Liability on Asset Category					
Time Period	NDDB4 on CCB4 x 10^{-2}	SAVDB4 on CCB4	TNSB4 on CCB4	NDDB4 on TSB4	SAVDB4 on TSB4	TNSB4 on TSB4
11	.2 *	0	.002 *	-.075*	1.6*	-.06 *
10	.6 *	.04*	.0058 *	.015	-2.2*	.025*
9	.59 *	-.33*	.0055 *	-.015	-2.4*	.01
8	.3 *	.09*	.0029 *	.04 *	-1 *	.045*
7	.08 *	0	.0005 *	.07 *	-1.2*	.07 *
6	.12 *	.06*	-.0015 *	.01	-1.2*	0
5	.41 *	-.29*	.0039 *	.015	-1 *	.012*
4	-.6 *	.33*	-.006 *	-.1 *	1.1*	-.12 *
3	-.38 *	.05*	-.004 *	-.125*	1.9*	-.13 *
2	-.3 *	-.1 *	-.003 *	-.14 *	-.2*	-.155*
1	-.2 *	-.16*	-.002 *	-.11 *	-1.6*	-.12 *
0	-.12 *	0	-.001 *	-.06 *	-.9*	-.075*
-1	.35 *	.09*	.0035 *	-.11 *	1 *	-.12 *
-2	-.3 *	.19*	-.0028 *	-.125*	-1 *	-.13 *
-3	0	-.15*	0	-.12 *	-.9*	-.125*
-4	-.405*	.18*	-.004 *	-.045*	.6*	-.04 *
-5	-.02 *	-.01*	-.0002 *	.075*	.1*	.075*
-6	.07 *	0	.001 *	-.015	.2*	0
-7	.53 *	-.34*	.0059 *	.1 *	-2.6*	.11 *
-8	0	0	.0002 *	.03 *	-.7*	.05 *
-9	.1 *	.3 *	.0015 *	.175*	.9*	.19 *
-10	-.07 *	-.08*	-.0002 *	.085*	1.9*	.11 *
-11	-.72 *	.11*	-.007 *	.015	4.3*	.05 *
-12	-.34 *	.03*	-3.3×10^{-3}*	.005	.5*	.025*

*Indicates coefficients that are significant at the 5% level.

significant. The implication is that perhaps a longer lead-lag time period should be used for this particular designation of the model.[2]

All of the significant coefficients for banks 1 and 3 are negative. All of the significant coefficients for bank 2 are positive. Bank 4's significant coefficients are half positive and half negative. The positive coefficients of bank 2 indicate that as net demand deposits increase or decrease, coin and currency for this bank moves in the same direction. This indicates that for bank 2 some of the funds which flow into the bank through net demand deposits are held for some time in the form of coin and currency. The negative coefficients for banks 1 and 3 indicate that coin and currency for these two banks move in the opposite direction of net demand deposits. Funds flowing in as net demand deposits in these two banks are not held long, i.e., less than one week, in the coin and currency category. For bank 4, the coefficients for lag periods 11 through 5 are positive. For lag period 4 through lead period 12, 11 of the 15 significant coefficients are negative. Bank 4 could build its coin and currency account in period t to a desired level from the inflows from net demand deposits for the t-N periods when the coefficients are positive. Once the coin and currency account is at a desired level the funds from net demand deposits in the periods with negative coefficients are channeled more quickly into other asset accounts.

Savings Deposits on Coin and Currency. This representation of the SGAM model shows banks 2, 3, and 4 with significant lead and lag

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[2]Spectral analysis was used to determine the necessary lead-lag period. This result suggests that spectral analysis might not be that accurate a predictor of the lead-lag relationship.

coefficients. As with the previous representation of this model the significant lag coefficients were expected and the significant lead coefficients were not. The explanations for the significant lead and lag coefficients in this design of the model are the same as those given for the NDD on CC representation of this model. This representation of the model for bank 1 shows only two significant coefficients. One is a 10 period lag coefficient, the other is the coefficient in time period 0, i.e., neither a lead nor a lag coefficient. The representation for bank 1 has no significant lead coefficients.

This representation of the model for bank 1 indicates that savings deposits are not a strong source of funds for coin and currency. For bank 3, 16 of 22 significant coefficients are negative. This indicates that for bank 3, funds from savings deposits either are not channeled or do not stay for long periods in coin and currency. Bank 2 has 15 of 24 significant coefficients positive. Bank 4 has 11 of 19 significant coefficients positive. The majority of positive coefficients for these two banks indicate that funds from savings deposits do flow into and are retained for some period of time in coin and currency.

Total Net Demand Deposits and Savings Deposits on Coin and Currency. This form of the SGAM model shows significant lead and lag coefficients for all four banks. The significance of the lead coefficients was not anticipated. The significance of the lag coefficients was anticipated. The explanation of the significant lead and lag coefficients is the same for this representation of the model as it was for the NDD on CC representation of the model.

The signs of most of the significant coefficients for all four banks in this representation of the model are the same as the signs of the significant coefficients for all four banks in the NDD on CC representation of the model. The explanation for this similarity is that net demand deposits dominate the total series, i.e., net demand deposits plus savings deposits. The explanation of the results for this representation of the model is the same as the explanation of the results for the NDD on CC form of the model.

Net Demand Deposits on Treasury Securities. Both significant lead and lag coefficients were found for all four banks using this representation of the SGAM model. As with previous representations, the significant lag coefficients for all banks were anticipated; the significant lead coefficients were not. Explanations for the significant lead and lag coefficients for this representation of the model are the same as those given for the NDD on CC representation of this model.

Two attributes of this representation for bank 1 are worth mentioning. First, all of the coefficients for bank 1 are significant. This indicates that a longer lead-lag structure for this particular representation of the model and for this particular bank might be in order. Second, 22 of the 24 coefficients are positive. This shows that the funds which come into the bank through net demand deposits do, in some form, flow into and stay within bank 1's treasury securities. This result has further significance when compared with the results of the NDD on CC representation for bank 1. All of the significant coefficients for the NDD on CC representation for bank 1 are negative. This indicated that if funds from net demand deposits flowed into the bank as coin and currency that these funds did not stay long in the coin and currency account, i.e., less than a week. It is quite probable, and the coefficients of the two models substantiate this, that net demand deposits flowing in the bank in the form of coin and/or currency are quickly transferred to some type of treasury security by bank 1.

For bank 2 all of the coefficients are significant and positive. The significance of all of the coefficients has the same implication as it did for bank 1. The fact that all the coefficients are positive indicates that funds from net demand deposits flow into and stay within the treasury securities account for bank 2. This representation and the NDD on CC representation both provide all positive coefficients. This indicates that funds from net demand deposits flow into and stay within these two asset accounts, i.e., coin and currency and treasury securities, for bank 2.

Bank 3 yields results which are the exact opposite of bank 2's, i.e., all of the significant coefficients are negative. These results are the same as those obtained for the NDD on CC representation of this model. The implication of all negative coefficients is the same for this representation of the model as it was for the NDD on CC representation for bank 3, i.e., funds may flow from net demand deposits into treasury securities, but if they do, they do not stay in the treasury security category very long.

This representation of the model for bank 4 yielded 10 of 17 significant coefficients which were negative. Unlike the first three banks, the signs of bank 4's coefficients come in no specific order. Any specific conclusions about the flow of funds for bank 4 would not be relevant. It does generally appear, however, that funds do not flow consistently from net demand deposits to treasury securities.

Savings Deposits on Treasury Securities. All of the banks using this specification of the SGAM model displayed significant lead and lag coefficients. The explanation for these significant lead and lag coefficients is the same as that given for the lead and lag coefficients of the NDD on CC specification of this model.

All of the coefficients are significant for banks 1, 2, and 4. This indicates that a longer lead-lag period might be appropriate for this representation of the model.

Nineteen of 24 significant coefficients for bank 1 are positive. This conflicts significantly with the SAVD on CC representation of this model in which only two of the coefficients are significant, and both of them are negative. The SAVD on CC representation shows that funds from savings deposits which do flow into the coin and currency category do not stay in the category very long. This representation of the model shows that funds from savings deposits do flow into treasury securities and stay there for some time.

Bank 2 has 16 of 24 significant coefficients positive. This indicates that funds from savings deposits do flow into and stay within treasury securities.

The majority of bank 3's significant coefficients are negative, i.e., 18 of 21. This result indicates that for bank 3 funds which flow into treasury securities from savings deposits that they do not stay very long in the account.

Bank 4 has 12 of 24 significant coefficients positive. There is no order among the significant coefficients, i.e., no positive or negative coefficient patterns emerge. No meaningful statements about funds flow from saving deposits to treasury securities for bank 4 can be made.

Total Net Demand and Savings Deposits on Treasury Securities. This designation of the SGAM model indicates significant lead and lag coefficients for all four banks. The explanation for these significant lead and lag coefficients is the same as the explanation given for both lead and lag coefficients for the NDD on CC representation of the model.

For banks 1 and 2, almost all of the significant coefficients are positive for each bank. The coefficient patterns for these two banks are very similar to the patterns for the NDD on TS and SAVD on TS designs of this model. The results of the current representation of the SGAM model for these two banks appear to provide no new information which was not already provided in the NDD on TS and SAVD on TS representation of the model.

The current representation for bank 3, like that for banks 1 and 2, provides little new information which is not already provided by the NDD on TS and SAVD on TS designs of this model. The difference between bank 3 and banks 1 and 2 for this design of the model is that the majority, 21 of 22, of the significant coefficients for bank 3 are negative.

For bank 4 this description of the model looks much more like the NDD on TS representation than then SAVD on TS representation. Net demand deposits so dominate the TNS category for bank 4 that the results for the NDD on TS and TNS on TS representations of the model are almost identical. As with the previous three banks this representation of the model provides no new information not provided by previous designs.

Conclusions About the SGAM Model. In reviewing the six representations of the SGAM model, no one representation appears to be better for all banks than any other representation. All of the representations appear to be bank dependent, i.e., the rankings of the representations depend upon which bank is being considered. The only clear result is that when the total of net demand deposits and savings deposits is used as the liability category, no new insight is obtained. This lack of new insight is the result regardless of whether coin and currency or treasury securities is used as the asset category.

Results of the SFM Model

This model has one liability and two asset categories. The one liability is the total of net demand, savings and time deposits. The two asset categories, which are held to be short-term assets, are coin and currency and treasury securities. The one liability and two asset categories allow for two representations, and their coefficients are presented in Tables X-XIII. Starting with Table X, each table displays the results for one bank. The Tables X-XIII correspond with the results for banks 1, 2, 3, and 4, respectively.

The Total of Net Demand, Savings and Time Deposits on Coin and Currency. All four banks have significant lead and lag coefficients. As with previous models the lag coefficients are anticipated, the lead coefficients are not. The significant lag coefficients indicate that there are sources of funds which find a use in the coin and currency account. The significant lead coefficients indicate that each bank's coin and currency account in period t is dependent upon anticipated deposits in periods t+N.

Bank 1 has only three significant coefficients. One is lag and two are lead. All these are negative which indicates that the funds which flow into coin and currency from net demand, savings and time

TABLE X

COEFFICIENTS FOR THE SFM FOR BANK 1

Time Period	Liability on Asset Category: TNSTB1 on CCB1 $\times 10^{-2}$	TNSTB1 on TSB1
11	-.12	.028*
10	.03	.041*
9	.23	.012*
8	-.08	-.05 *
7	-.08	-.07 *
6	-.04	-.004*
5	-.08	.05 *
4	.12	.039*
3	-.15	.015*
2	-.3 *	.028*
1	-.18	.019*
0	-.07	.005*
-1	-.4 *	.019*
-2	-.02	-.001*
-3	.1	-.012*
-4	.01	.021*
-5	-.01	.042*
-6	.01	.01 *
-7	-.07	-.015*
-8	-.07	-.018*
-9	-.01	.008*
-10	.13	.01 *
-11	-.32*	-.008*
-12	.14	.03 *

*Indicates coefficients that are significant at the 5% level.

TABLE XI

COEFFICIENTS FOR THE SFM FOR BANK 2

Time Period	Liability on Asset Category: TNSTB2 on CCB2 $\times 10^{-2}$	TNSTB2 on TSB2
11	.045*	.052*
10	.1 *	.037*
9	.16 *	.01 *
8	.13 *	.022*
7	.045*	.054*
6	.05 *	.042*
5	.075*	.035*
4	-.01 *	.039*
3	.075*	.035*
2	-.21 *	.08 *
1	.03 *	.053*
0	.11 *	.007*
-1	-.3 *	.02 *
-2	.12 *	.03 *
-3	.16 *	.039*
-4	.28 *	.055*
-5	-.01 *	.045*
-6	.08 *	.024*
-7	.03 *	.039*
-8	.02 *	.042*
-9	-.07 *	-.011*
-10	-.25 *	0
-11	.03 *	0
-12	-.15 *	.026*

*Indicates coefficients that are significant at the 5% level.

TABLE XII

COEFFICIENTS FOR THE SFM FOR BANK 3

Time Period	Liability on Asset Category: TNSTB3 on CCB3	TNSTB3 on TSB3
11	.004 *	0
10	-.0022*	.004
9	.0016	.007
8	.0005	.01 *
7	-.0002	-.014*
6	.0009	-.008
5	.0016	-.002
4	-.0007	-.008
3	-.0028*	.022*
2	.001	.009
1	.0025*	.03 *
0	.0175*	.069*
-1	.002 *	.014*
-2	.0012	.005
-3	.0012	.005
-4	-.001	.01 *
-5	.002 *	.028*
-6	.0032*	.058*
-7	.0017*	-.013*
-8	-.0035*	-.01
-9	.001	-.013*
-10	-.0002	-.013*
-11	-.001	-.005
-12	-.002 *	.002

*Indicates coefficients that are significant at the 5% level.

TABLE XIII

COEFFICIENTS FOR THE SFM FOR BANK 4

Time Period	Liability on Asset Category: TNSTB4 on CCB4 x 10^{-2}	TNSTB4 on TSB4
11	-.11*	-.1 *
10	.37*	.02 *
9	.12*	-.03 *
8	.29*	.01 *
7	.09*	0
6	.01*	-.051*
5	.07*	-.045*
4	-.7 *	-.1 *
3	-.26*	-.05 *
2	-.1 *	0
1	.29*	.12 *
0	-.13*	.23 *
-1	.44*	.2 *
-2	-.29*	.05 *
-3	.2 *	-.09 *
-4	.05*	-.17 *
-5	0	-.1 *
-6	.1 *	-.1 *
-7	.07*	.095*
-8	-.3 *	.02 *
-9	-.04*	.095*
-10	.19*	-.025*
-11	-.41*	-.055*
-12	-.1 *	-.03 *

*Indicates coefficients that are significant at the 5% level.

deposits do not stay in coin and currency for a significant, i.e., longer than one week, period of time.

All but one of the coefficients for banks 2 and 4, respectively, are significant. This fact suggests that a lead-lag structure of longer than 12 periods might provide a better representation of the SFM model for these two banks. The majority of coefficients for both banks are positive indicating that funds from total net demand, savings and time deposits do stay in the coin and currency account for a period of time greater than one week. There is no specific pattern for the signs of the coefficients for these two banks.

Bank 3 has 10 significant coefficients, four of which are negative. This bank's significant coefficients form no specific pattern as to size or sign. No specific statements about this representation for this bank can be made.

The Total of Net Demand, Savings and Time Deposits on Treasury Securities. This representation of the SFM model has significant lead and lag coefficients for all four banks. As with the previous representation the significant lag coefficients were expected; the significant lead coefficients were not. The explanation for both is the same as for the previous representation.

Banks 1 and 2 have all or almost all of their coefficients significant which indicates that for this representation of the model for these two banks a longer lead-lag structure might be more appropriate.

Bank 1 has 15 of 24 significant coefficients positive. It appears that funds from total net demand, savings and time deposits flow into treasury securities and stay within treasury securities for longer than one week's time. This representation of the SFM model for bank 1 when compared to the TNST on CC representation for bank 1 shows that funds from net demand, savings and time deposits stay longer in treasury securities than in coin and currency.

Bank 2 has 21 of 22 significant coefficients positive. This indicates that for bank 2 funds from net demand, savings and time deposits do flow into and stay within treasury securities. This representation of the model compared with the TNST on CC representation for this bank shows that funds from the TNST deposit category flow into both coin and currency and treasury securities for periods of time greater than one week.

The results from this representation for bank 3 are very much the same as the results from the TNST on CC representation of this model. Six of the 10 significant coefficients are positive. There is no pattern to the signs of the coefficients and, therefore, no specific statements about this representation for this bank can be made.

Bank 4 has 13 of 21 significant coefficients negative. However, by far the largest of the coefficients are positive. With this representation for this bank it would be very hard to determine, simply by looking at the significant coefficients, the relationship between total net demand, savings and time deposits and treasury securities.

Conclusions About the SFM Model. The results for this model are certainly bank dependent. Banks 3 and 4 do not create any pool of cash or near cash assets.[3] The results for both banks for both representations are at best difficult to interpret. Bank 2 looks like the only bank where

[3] Assuming that coin and currency and treasury securities are an appropriate measure of the bank's cash and near cash assets.

a positive change in total net demand, savings and time deposits, coincides with a positive change in both coin and currency and treasury securities. Bank 1 does not put its funds which flow into the bank with a change in net demand, savings and other time deposits into coin and currency for a significant length of time. This bank does appear, however, to channel some of the funds inflow from the deposits into treasury securities.

A comparison of the dollar amounts of the changes in total net demand, savings and other time deposits to the dollar amounts of the changes for coin and currency plus treasury securities confirms that none of the four banks is placing more than approximately 50 percent of these deposit inflows into both asset categories. The only banks which could be creating a pool of funds are bank 2 and maybe bank 1. The above comparisons indicate that while some of the deposit inflows move into one or both of these asset categories for the two banks, there is still enough of the inflows, i.e., approximately 50 percent, which do not flow into what this study is calling cash and near cash assets to indicate a lack of the total pooling of funds.

Results of the SCAM Model

The data for this model differ from that used for the previous three models. For this model the data for the liability categories have been filtered so that only the short-term component of each deposit category will be compared with the asset category.

For this model six liability and two asset categories are used to create 12 different representations of the SCAM model. The two asset categories, coin and currency and treasury securities, are used because they represent the short-term asset categories of each bank. The six liability categories: net demand deposits; savings deposits; other time deposits; total net demand, savings and other time deposits; and total net demand and other time deposits are used because a short-term component for each liability category is a potential source of funds for the short-term assets.[4]

The coefficients for these representations are presented in Tables XIV-XVII. Table XIV gives the results of the 12 representations of this model for bank 1. Table XV gives the results of the 12 representations of this model for bank 2. Bank 3's results of the 12 representations are shown in Table XVI. Table XVII gives the results of the 12 representations for bank 4. As with the previous models, each representation presented will show the results for all four banks.

The Short Term Component of Net Demand Deposits on Coin and Currency. This representation of the model for bank 1 has 14 of 23 coefficients positive. There is no specific pattern for either the positive or negative coefficients. Both lead and lag coefficients are significant. The lag coefficients were expected to be significant, the lead coefficients were not. The significance of the lag coefficients is explained as a source of funds finding a use. This is to say that the change in the short term component of net demand deposits in period t-N provides funds which are used in coin and currency in period t. The significance of the lead coefficients is explained by anticipation. The coin and

[4]The total of savings and other time deposits is the only combination of the liability categories which is not used. The other three combinations of the liability categories which are used should give sufficient evidence of this type activity by any of the banks.

TABLE XIV

COEFFICIENTS FOR THE SCAM FOR BANK 1

Time Period	NDDSB1 on CCB1 x 10^{-2}	SAVDSB1 on CCB1	TNSSB1 on CCB1 x 10^{-2}	TNSTSB1 on CCB1 x 10^{-3}	TNTSB1 on CCB1 x 10^{-3}	NDDSB1 on TSB1	OTDSB1 on TSB1	SAVDSB1 on TSB1	TNSSB1 on TSB1	TSTSB1 on TSB1	TNSTSB1 on TSB1	OTDSB1 on CCB1 x 10^{-2}
	Liability on Asset Category											
11	.37*	-.06*	-.026*	.008*	.008*	-.015*	.001	.12*	.0015	.003*	.001	.057*
10	-.32*	.13	-.04*	-.25*	-.3*	-.045*	-.011	.1*	.0025*	-.001	0	-.035*
9	.3*	-.047*	-.085*	-.52*	-.58*	-.08*	-.012	-.5*	-.019*	-.011*	-.008*	-.051*
8	-.05*	.019*	.09*	.55*	.59*	-.01*	-.009	.2*	-.022*	-.022*	-.013*	-.075*
7	.39*	-.041*	0	.005*	.05*	.013*	.002	.75*	.047*	.035*	.023*	.17*
6	-.3*	-.001	.01*	-.002*	-.002*	.0625*	.00175*	.6*	.025*	.034*	.016*	.04*
5	.15*	-.04*	-.035*	-.25*	-.23*	-.022*	.00175*	.35*	-.02*	-.021*	-.013*	-.1*
4	-.09*	-.32*	0	0	0	-.015*	-.004	.3*	0	-.003*	.0017	-.1*
3	.2*	.01	-.160*	-.65*	-.67*	-.008*	-.016	.3*	.005*	.002*	.0035*	.135*
2	-.23*	-.32*	.05*	.1*	.1*	.008*	-.008	.39*	.009*	.012*	.0055*	.07*
1	.22*	-.32*	.088*	.39*	.4*	-.015*	.012	.2*	-.031*	-.034*	-.019*	-.051*
0	.61*	.063*	.09*	.6*	.62*	-.012*	.0018*	1.3*	.03*	-.029*	.0148*	.05*
-1	.15*	-.018*	.124*	.63*	.7*	.018*	0	-.9*	.015*	.011*	.0075*	.1*
-2	.31*	-.041*	-.03*	-.2*	-.2*	-.02*	.0075	1.25*	-.015*	-.011*	-.006*	-.025*
-3	-.2*	.07*	-.09*	-.58*	-.6*	.01*	.024*	-.1*	-.017*	-.011*	-.0075*	-.085*
-4	.1*	-.15*	-.076*	-.45*	-.5*	-.025*	-.013	.75*	.004*	-.003*	-.001	-.03*
-5	-.08*	.07*	.015*	.19*	.19*	-.022*	-.0055	-.35*	-.005*	-.003*	-.003*	.04*
-6	.41*	-.03*	.06*	.41*	.42*	-.05*	-.015	.1*	-.015*	-.005*	-.0055*	.051*
-7	-.3*	-.021*	.055*	.1*	.13*	-.03*	-.0025	.4*	.014*	.015*	-.009*	.045*
-8	.2*	-.018*	-.0355*	-.19*	-.19*	.035*	.001	.4*	.001	-.003*	-.0017	-.052*
-9	-.1*	-.02*	-.11*	-.5*	-.52*	-.01*	-.0045	.55*	.028*	.02*	.012*	-.05*
-10	.11*	-.12	-.01*	.005*	.008*	-.028*	.0045	.05*	-.011*	-.004*	-.005*	.02*
-11	.11*	-.021*	.025*	.1*	.1*	-.075*	.0125	-.5*	-.027*	-.027*	.0125*	.098*
-12	0*	-.018*	.11*	.49*	.5*	.026*	.0045	.7*	.009*	.012*	.007*	-.045*

*Indicates coefficients that are significant at the 5% level.

TABLE XV

COEFFICIENTS FOR THE SCAM FOR BANK 2

	Liability on Asset Category											
Time Period	NDDSB2 on CCB2	SAVDSB2 on CCB2	TNSSB2 on CCB2	TNSTSB2 on CCB2 x 10^{-2}	TNTSB2 on CCB2 x 10^{-2}	NDDSB2 on TSB2 x 10^{-2}	SAVDSB2 on TSB2	TNSSB2 on TSB2	TSTSB2 on TSB2	TNSTSB2 on TSB2	OTDSB2 on TSB2	OTDSB2 on CCB2
11	-.003	.2 *	-.0035*	.15*	.12*	.65	-1.5 *	.002*	.01 *	.0025*	.018*	-.003
10	.0045	-.32*	.01 *	.06	-.08*	-.2	-1.3 *	-.011*	-.005 *	-.0035*	-.007	.03 *
9	-.0055	.62*	-.0046*	.22*	.25*	-.78	-1.65*	-.008*	-.02 *	-.008 *	.009	-.01
8	.004	-.51*	-.0082*	-.2 *	-.16*	-1 *	-1.9 *	-.003*	-.01 *	-.0045*	0	-.017
7	-.001	.1 *	.014 *	.29*	.27*	.2	-1.48*	-.008*	.001 *	0	.014*	.016
6	.004	.19*	-.0082*	-.3 *	-.3 *	.85	-1.28*	0	.0048*	.001 *	.01 *	-.032*
5	0	-.35*	.0043*	.2 *	.18*	.4	-1.22*	.005*	0	.001 *	.004	.09 *
4	-.002	.4 *	-.005 *	.04	0	-.35	-1.9 *	0	-.017 *	-.0055*	.004	-.122*
3	-.003	-.15*	.0042*	.08*	.1 *	-.9	-.82*	-.002*	-.005 *	-.0025*	-.018*	.095*
2	.002	-.21*	-.0025*	-.26*	-.24*	-.55	-1.55*	.009*	.02 *	.009 *	-.005	-.042*
1	.003	.21*	-.002 *	-.1 *	-.1 *	.23	-1.1 *	.002*	.005 *	.0025*	.063*	.02 *
0	.002	.19*	.0058*	.42*	.37*	.6	.13*	.028*	.016 *	.0125*	.125*	-.013
-1	-.001	-.19*	-.0025*	-.11*	-.08*	1.25*	-1.55*	.04 *	.029 *	.02 *	.04 *	.059*
-2	-.001	.02*	.0019*	.07	0	.48	-.95*	.01 *	.011 *	.006 *	-.005	-.1 *
-3	-.001	.09*	.0002	-.16*	-.06	-.25	-1.48*	-.02 *	-.011 *	-.009 *	.009	.088*
-4	-.002	-.28*	-.0021*	-.16*	-.21*	-1.2 *	-1.48*	-.035*	-.027 *	-.016 *	-.02 *	-.06 *
-5	.0047	.3 *	.0015*	.33*	.19*	-.1	-1.55*	-.014*	-.016 *	-.0075*	.014*	.015
-6	-.0025	-.18*	-.0021*	-.3 *	-.05	1.38*	-1.58*	.011*	.001 *	.0025*	.01 *	0
-7	.005	.16*	.0042*	.25*	.13*	1.17*	-1.29*	.011*	.014 *	.006 *	0	.007
-8	-.008	-.25*	.0019*	.22*	.22*	1 *	-1.2 *	0	.016 *	.0048*	-.021*	-.017
-9	.016 *	.19*	-.0075*	-.55*	-.55*	-1.2 *	-1.1 *	-.014*	-.001 *	-.0025*	-.01 *	.01
-10	-.0035	.02*	.0033*	.14*	.16*	-.7	-1.81*	-.007*	-.014 *	-.006 *	.008	.004
-11	-.025 *	-.09*	.0017*	.02	.05	-.1	-1.35*	.007*	-.005 *	-.001 *	-.025*	-.003
-12	.014	-.1 *	.002 *	.08*	-.08*	1.12*	-1.48*	.002*	.006 *	.002 *	.028*	-.017

*Indicates coefficients that are significant at the 5% level.

TABLE XVI

COEFFICIENTS FOR THE SCAM FOR BANK 3

Time Period	Liability on Asset Category											
	NDDSB3 on CCB3	SAVDSB3 on CCB3	TNSSB3 on CCB3	TNTSB3 on CCB3 x 10^{-2}	TNSTSB3 on CCB3 x 10^{-2}	NDDSB3 on TSB3	SAVDSB3 on TSB3	TNSSB3 on TSB3	TSTSB3 on TSB3	TNSTSB3 on TSB3	OTDSB3 on TSB3	OTDSB3 on CCB3
11	.0048	-.18 *	.0005	.17*	.19 *	-.051*	1.2 *	.013*	.003*	.003*	-.498*	-.0005
10	-.0048	-.1 *	-.0047*	-.03*	.07 *	-.047*	.75*	-.01 *	-.004*	-.004*	-.521*	.0025
9	-.002	-.275*	-.0062*	-.36*	-.36 *	-.08 *	.11*	-.027*	-.004*	-.007*	-.534*	-.011
8	.014	.05 *	.0028*	-.17*	-.23 *	-.09 *	.5 *	-.015*	.003*	-.002*	-.523*	.0025
7	.024	-.055*	.007 *	.29*	.29 *	-.065*	.95*	.021*	.009*	.008*	-.509*	-.004
6	.001	-.045*	.0062*	.48*	.47 *	-.03 *	1 *	.024*	.005*	.006*	-.509*	.018*
5	.005	-.19 *	-.0052*	.05*	.1 *	-.075*	.6 *	.012*	-.005*	0	-.498*	-.004
4	-.0055	-.255*	.001 *	-.2 *	-.22 *	-.075*	.75*	-.037*	-.02 *	-.014*	-.52 *	-.014
3	.0098	-.025*	.0008	-.34*	-.35 *	-.12 *	.8 *	-.034*	-.015*	-.013*	-.481*	0
2	.014	-.025*	.0003	.03*	.08 *	-.07 *	.6 *	.01 *	.002*	.003*	-.509*	0
1	.002	-.15 *	.0015*	.4 *	.39 *	.07 *	1.37*	.038*	.02 *	.016*	-.481*	.0045
0	-.01	-.35 *	-.0045*	-.1 *	-.02 *	.13 *	3.4 *	.082*	.058*	.035*	-.435*	0
-1	.005	-.12 *	-.0042*	-.4 *	-.37 *	.024*	.5 *	.033*	.022*	.014*	-.479*	-.017*
-2	.006	-.046*	.003 *	-.15*	-.2 *	-.07 *	.6 *	-.034*	-.021*	-.015*	-.482*	-.005
-3	.0095	-.05 *	.0019*	.18*	.16 *	-.085*	1.1 *	-.041*	-.035*	-.023*	-.49 *	.007
-4	-.004	-.275*	-.0041*	.11*	.1 *	-.055*	1 *	-.014*	-.023*	-.013*	-.511*	.003
-5	-.0025	-.21 *	-.0019*	-.03*	.1 *	-.03 *	.8 *	.012*	.003*	.003*	-.545*	-.0051
-6	.015	.01 *	.0052*	.01*	-.09 *	-.02 *	.6 *	.02 *	.015*	.01 *	-.488*	-.003
-7	.02	.07 *	.0059*	.12*	.05 *	-.02 *	1.1 *	.007*	.012*	.005*	-.514*	.005
-8	.004	-.265*	-.003 *	.03*	.06 *	-.03 *	1.1 *	.001*	0	0	-.466*	.007
-9	-.008	-.11 *	-.0065*	-.13*	-.1 *	-.065*	.8 *	-.018*	-.014*	-.009*	-.491*	-.0025
-10	-.004	-.28 *	-.0041*	-.25*	-.15 *	-.05 *	.8 *	-.011*	-.01 *	-.005*	-.54 *	-.01
-11	.019	.08 *	.0065*	.05*	-.001*	-.055*	1 *	-.005*	.005*	.004*	-.495*	.002
-12	.023	.01 *	.0082*	.24*	.19 *	-.09 *	.6 *	.001*	.007*	.004*	-.489*	.01

*Indicates coefficients that are significant at the 5% level.

TABLE XVII

COEFFICIENTS FOR THE SCAM FOR BANK 4

Time Period	NDDSB4 on CCB4 x 10^{-2}	SAVSSB4 on CCB4	TNSSB4 on CCB4 x 10^{-2}	TNTSB4 on CCB4 x 10^{-2}	TNSTSB4 on CCB4 x 10^{-2}	NDDSB4 on TSB4	SAVDSB4 on TSB4	TNSSB4 on TSB4	TSTSB4 on TSB4	TNSTSB on TSB4	OTDSB4 on TSB4	OTDSB4 on CCB4
	Liability on Asset Category											
11	-.82*	.17 *	-.2 *	-.125*	-.135*	-.025*	-2.2 *	-.041*	-.03 *	-.024*	.015*	-.013
10	-.47*	.29 *	-.11*	-.075	-.08 *	-.01 *	-1 *	-.06 *	-.019*	-.018*	-.003	.0052
9	.1 *	.29 *	-.08*	.02	.001*	-.03 *	0	-.008*	-.009*	-.004*	-.02 *	-.005
8	-.19*	.3 *	.29*	.15 *	.15 *	.11 *	-.25*	.04 *	.015*	.014*	0	.0052
7	-.5 *	.17 *	.07*	.03	.025*	-.01 *	-1.5 *	.03 *	.01 *	.007*	.019*	-.011
6	-.5 *	.275*	-.11*	-.09	-.08 *	-.09 *	-1.3 *	-.019*	.001*	-.005*	-.003	0
5	-.1 *	.31 *	-.48*	-.225*	-.22 *	-.08 *	-1.3 *	-.21 *	-.001*	-.005*	-.012*	.001
4	-.45*	.125*	.17*	.12	.12 *	-.07 *	-1.4 *	-.21 *	-.01 *	-.007*	-.02 *	-.009
3	-.75*	.31 *	.31*	.19 *	.19 *	-.14 *	-.8 *	-.08 *	-.065*	-.039*	0	-.015
2	-.6 *	.335*	-.55*	-.255*	-.24 *	-.08 *	-.8 *	.02 *	.016*	.009*	-.022*	-.0021
1	.59*	.27 *	.05*	.02	.001	.1 *	-2.8 *	.03 *	.05 *	.024*	.005	.008
0	.79*	.34 *	.54*	.24 *	.22 *	.08 *	2.7 *	.04 *	.038*	.021*	.158*	0
-1	.3 *	.29 *	.54*	.26 *	.25 *	.21 *	-.5 *	.11 *	.058*	.044*	.11 *	.002
-2	.39*	.25 *	-.21*	-.055	-.05 *	.14 *	-.55*	.039*	.001*	.009*	-.021*	-.004
-3	-.75*	.375*	-.38*	-.205*	-.2 *	-.052*	-1.5 *	-.061*	-.048*	-.03 *	-.038*	.0052
-4	0	.15 *	-.37*	-.175*	-.16 *	-.13 *	-1.4 *	-.082*	-.052*	-.035*	-.021*	-.0062
-5	-1.1 *	.32 *	.28*	.075	.06 *	.03 *	-1 *	-.011*	.014*	.004*	.019*	-.0021
-6	.39*	.148*	.19*	.14 *	.12 *	.05 *	-.5 *	.061*	.032*	.028*	-.012*	-.0028
-7	-.55*	.42 *	-.1 *	-.01	.0007	0	-.55*	.05 *	.02 *	.019*	-.022*	-.001
-8	-.3 *	.22 *	.12*	.04	.035*	-.05 *	-2 *	-.037*	-.02 *	-.015*	-.034*	-.0025
-9	-.35*	.11 *	-.35*	-.21 *	-.2 *	0	-.55*	-.08 *	-.039*	-.029*	-.003	-.001
-10	-.62*	.37 *	-.02*	-.04	-.04 *	.08 *	-.75*	-.019*	-.001*	-.001*	-.012*	-.013
-11	.19*	.275*	.19*	.1	.09 *	.07 *	-.01*	.092*	.035*	.032*	-.02 *	.0053
-12	-.01	.275*	.35*	.17 *	.17 *	.07 *	-.03*	.042*	.008*	.009*	.012*	.0013

*Indicates coefficients that are significant at the 5% level.

currency held by the bank in period t depends on the anticipated change in the short term component of net demand deposits in periods t+N.

It is interesting to remember that this representation of the SGAM model has all negative coefficients. This indicated that bank 1 did not leave the funds from total net demand deposits in the form of coin and currency for very long. Now, with this representation of the SCAM model, a majority of the coefficients are positive. This indicates that the short-term component of net demand deposits is correlated in a positive manner with coin and currency, i.e., the short-term component of net demand deposits does stay within coin and currency for a significant period of time.

Bank 2 for this representation has only two lead coefficients which are significant. One is positive the other negative. It is obvious, for these results, that the short-term component of net demand deposits has no significant relationship with this bank's coin and currency. This representation for the SGAM model, however, has 23 positive, significant coefficients. This indicates that for bank 2 it is the total net demand deposit category which correlates well with coin and currency.

This representation for bank 3 shows all coefficients to be insignificant. This indicates that no relationship between the short-term component of net demand deposits and coin and currency exists for bank 3. The results from this representation for this model go beyond the results from this representation for the SGAM model. This representation for the SGAM model provided 24 significant negative coefficients. This indicates that a negative relationship exists which in turn implies that the funds from net demand deposits do not stay within the coin and currency account for a significant period of time. This representation for the SCAM model goes beyond a negative relationship and indicates that for the short-term component there exists no relationship at all.

Bank 4 has 22 significant coefficients, 15 of which are negative. There are no discernible patterns in the coefficients. Any interpretation is therefore mere conjecture. This corresponds with the results for this representation of this bank for the SGAM model. The results from this representation of the SGAM model are also unclear.

The Short Term Component of Savings Deposits on Coin and Currency. All four banks for this representation of the model have significant lead and lag coefficients. The significant lag coefficients were anticipated. The significant lead coefficients were not anticipated. The explanation for the significance of both the lead and lag coefficients is the same as that presented for the previous representation.

For this representation, bank 1 has 20 significant coefficients, 15 of which are negative. The negative relationship for this representation indicates that funds from the short-term component of savings deposits do not stay within coin and currency for a significant length of time, i.e., longer than a week. In comparing this representation to the previous one, i.e., NDDS on CC, it appears that for the SCAM model for this bank that coin and currency is more closely related to the short-term component of net demand deposits than to the short-term component of savings deposits.

Bank 2 has 22 significant coefficients. Eleven are negative. There is no discernible pattern to either the positive or negative coefficients. Any explanation of this representation of the model for bank 2 would only be speculation. Comparing this design of the model to the previous design, i.e., NDD on CC, shows that for the current design a significant relationship does exist but is not explainable; while for the previous representation no significant relationship even existed.

Bank 3 has 22 significant coefficients, 19 of which are negative. This implies that the short-term component of savings deposits for bank 3 does not remain in the form of coin and currency for very long. Comparing this representation of the SCAM model to this representation of the SGAM model shows that for bank 3 neither the short-term component of savings deposits nor total savings deposits remain in coin and currency for very long, i.e., more than one week.

For bank 4, all 24 coefficients are significant and positive. With all of the coefficients being significant, it is possible that a longer lag structure is needed for bank 4. The previous representation for this model, i.e., NDDS on CC, has a majority of negative significant coefficients. This indicates that for bank 4 the funds from the short-term component of net demand deposits do not stay within the coin and currency category very long. In contrast, this representation indicates that the funds from the short-term component of savings deposits stays within the coin and currency category for a longer period. The comparison indicates that for bank 4 the short-term component for savings deposits is more important in providing coin and currency.

<u>The Short Term Component of Total Net Demand and Savings Deposits on Coin and Currency</u>. This representation of the model yields results which are very similar for each of the four banks. All four banks have almost one-half of their significant coefficients positive. Each bank has between 20 to 24 significant coefficients with 10 to 12 of the

coefficients positive. None of the significant coefficients for any of the four banks has a particular or distinguishable pattern. An interpretation for any of the four banks would be pure speculation and is therefore undesirable.

All four banks also have significant lead and lag coefficients. The signifcant lag coefficients were expected; the significant lead coefficients were not. The explanation for having both significant lead and lag coefficients for this representation of the model is the same as that given for the NDDS on CC representation.

The results from this representation of the SCAM model yield very little information. Comparing these results to the results of this representation for the SGAM model, it appears that this representation gives much less information than the SGAM model.

The Short Term Component of Net Demand and Other Time Deposits on Coin and Currency. For this representation of the model, banks 1, 2, 3, and 4 have 22, 18, 24, and 12 significant coefficients, respectively. As with the previous representation, each bank has approximately one-half of its significant coefficients negative. There is no specific pattern for the positive or negative coefficients of any of the four banks. Bank 3 has all of its coefficients significant. This means that a longer lead and lag structure might be a better representation of this model for bank 3. However, any attempted interpretation of any of the four banks' coefficients would be meaningless.

All four banks do have significant lead and lag coefficients. As with previous representations, the significant lag coefficients were anticipated; the significant lead coefficients were not. The explanation for the significant lead and lag coefficients is the same as that given for the NDDS on CC representation of this model.

The Short Term Component of Total Net Demand, Savings and Other Time Deposits on Coin and Currency. This representation of the SCAM model yields results very similar to the previous two representations. All four banks have significant lead and lag coefficients. The significant lead coefficients were not anticipated; the significant lag coefficients were anticipated. An explanation of both the significant lead and lag coefficients is given in the explanation of the NDDS on CC representation of this model.

Banks 1, 2, 3, and 4, have 22, 16, 23, and 21 significant coefficients, respectively. They also have 13, 10, 13, and 11 of their significant coefficients positive, respectively. The positive and negative coefficients occur in no specific pattern. Therefore, no attempt will be made to interpret the pattern of coefficients for any of the four banks.

The Short Term Component of Net Demand Deposits on Treasury Securities. For this representation of the SCAM model, banks 1, 3, and 4 have both significant lead and lag coefficients. Bank 2 has only significant lead coefficients. An explanation of the significant lead and lag coefficients is given in the NDDS on CC representation of this model.

Bank 1 has 17 of 24 significant coefficients negative. This implies that the short-term component of net demand deposits does not stay within the treasury security categories very long for bank 1. When this representation of the SCAM model is compared to the NDDS on CC representation with 14 of its 23 significant coefficients positive, it appears that the short-term component of net demand deposits is more closely related to coin and currency than to treasury securities. Also, when this representation is compared to the NDD on TS representation for the SGAM model, it indicates that the treasury security category is more closely related to the total net demand deposit category than it is to the short-term component.

Bank 2 has six significant lead coefficients; four of the six are positive. With this few significant coefficients, it appears that for bank 2 the short-term component for net demand deposits is not strongly related to treasury securities. This result coupled with the result of the NDDS on CC representation of this model indicate that the short-term component of net demand deposits is not an important input into either of the short-term asset categories, i.e., coin and currency or treasury securities. This representation of the SGAM model further shows that it is the total net demand deposits and not the short-term component which is the most significant input into the treasury security category.

Bank 3 has 19 of 22 significant coefficients negative. This implies that funds from the short-term component of net demand deposits do not stay within the treasury security category for very long, i.e., longer than one week. This result coupled with the result from this representation for the SGAM model indicate that for bank 3 neither the short-term component nor total net demand deposits stay within the treasury security category for very long.

Bank 4 has 22 significant coefficients, 12 of which are negative. Nine of the 11 significant lag coefficients are negative while eight of the 11 significant lead coefficients are positive. This indicates that funds which have already come into the bank through the short-term component of net demand deposits do not stay within the treasury security category very long. However, anticipated funds from future periods from the short-term component of net demand deposits are expected to contribute to the treasury security category.

The Short Term Component of Savings Deposits on Treasury Securities. Banks 1, 2, and 3 in this representation of the model have all 24 coefficients significant. This implies that for these banks a model with longer leads and lags might be more appropriate.

Also, for this representation, all four banks have both significant lead and lag coefficients. An explanation for having both significant lead and lag coefficients is given in the NDDS on CC representation of this model.

Bank 1 for this representation has 24 significant coefficients, 19 of which are positive. This indicates that funds from the short-term component of savings deposits stay within the treasury security category for longer than one week. This result when compared to the result of the SAVDS on CC representation of this model shows that for bank 1 the short-term component of savings deposits remains within the treasury security category longer than in the coin and currency category.

Bank 2 has 23 negative out of 24 significant coefficients. This indicates that funds from the short-term component of savings deposits do not stay with the treasury security category long enough to indicate a positive relationship. This result compared to the result of this representation for the SGAM model indicates that the total category of savings deposits for bank 2 is more positively related to the treasury security than is the short-term component of savings deposits.

Bank 3 has all 24 of its significant coefficients positive; thus indicating that the funds from the short-term component of savings deposits remain within the treasury security category for a period of time greater than one week. This result compared with the result of the SAVDS on CC representation for this model indicates that funds from the short-term component of savings deposits remain within treasury securities longer than they remain within coin and currency. Also, the results from this representation compared with the results of the representation for the SGAM model indicate that for bank 3 it is the short term component of savings deposits and not total savings deposits which stays within the treasury security category the longest. These results are just the opposite of those found for bank 2.

For this representation, bank 4 has 22 significant coefficients. Twenty-one of the 22 significant coefficients are negative. This implies that funds from the short-term component of savings deposits do not remain within the treasury security category for more than one week. This result contrasts with the result for the SAVDS on CC representation of the model. For bank 4 it appears that funds from the short-term component of savings deposits are more positively related to coin and currency than to treasury securities. This result is exactly opposite of the results found for banks 1 and 3.

<u>The Short Term Component of Total Net Demand and Savings Deposits on Treasury Securities</u>. All four banks for this representation of the model have both significant lead and lag coefficients. As with previous representations, the significant lead coefficients were not expected.

The significant lag coefficients were expected. For an explanation of both the significant lead and lag coefficients see the NDDS on CC representation for this model appearing on page 84.

Banks 1, 2, 3, and 4 have 21, 20, 22, and 24 significant coefficients, respectively. All four banks have 11 of their significant coefficients positive. None of the positive or negative coefficients for any of the banks display a specific pattern or sequence. Because none of the banks' significant coefficients have a clear cut pattern or sign, any attempt to interpret the results would be mere conjecture. Comparing the results for this representation of this model with those for this representation for the SGAM model indicate that the total of net demand and savings deposits, for banks 1, 2, and 3, has a much stronger relationship with treasury securities than does the short-term component of net demand and savings deposits.

The Short Term Component of Other Time Deposits on Treasury Securities. For this representation of the model all four banks have both significant lead and lag coefficients. As with previous representations and models the significant lag coefficients were anticipated and the significant lead coefficients were not. For an explanation of both the significant lead and lag coefficients see the explanation given in the NDDS on CC representation of this model appearing on page 84.

Bank 1 has only four significant coefficients; all of which are positive. The four significant coefficients indicate that the short-term component of other time deposits is, at best, very weakly related to treasury securities.

Bank 2 has 11 significant coefficients, seven of which are positive. This indicates that for bank 2 there is a stronger, i.e., stronger than bank 1's relationship, relationship between the short-term component of other time deposits and treasury securities.

Bank 3 has all of its coefficients significant and negative indicating that the funds from the short-term component of other time deposits do not stay within the treasury security category for a very long period of time. These results also indicate that for bank 3 there is a strong relationship between the short-term component of other time deposits and the treasury security category. Comparing the results of this representation of this model with the results of the OTDS on CC representation of this model shows that for bank 3 the short-term component of other time deposits is much more strongly related to treasury securities than to coin and currency.

Bank 4 has 13 of 18 significant coefficients negative. This indicates that funds from the short-term component of other time deposits do not stay within the treasury security category for longer than one week. The results also indicate that the negative relationship between the short-term component of other time deposits and treasury securities is not a very strong one.

The Short Term Component of Other Time Deposits on Coin and Currency. For all practical purposes, this representation of the model has only two banks with both significant lead and lag coefficients. Bank 3 has only two significant coefficients while all of the coefficients for bank 4 are insignificant. The explanation of the significant lead and lag coefficients for banks 1 and 2 is the same as that given for the significant lead and lag coefficients in the NDDS on CC representation of this model.

The results for banks 3 and 4 indicate that for these two banks there is no relationship between the short-term component of other time deposits and coin and currency. Bank 2 has six of 11 significant coefficients positive, while bank 1 has 10 of 23 significant coefficients positive. Neither of the sets of significant coefficients for banks 1 or 2 have a specific pattern for the positive or negative coefficients. Therefore, no attempt is made to interpret the pattern of coefficients for banks 1 or 2.

The Short Term Component of Total Savings and Other Time Deposits on Treasury Securities. For this representation of the model all four banks have significant lead and lag coefficients. An explanation for the existence of both significant lead and lag coefficients is given in the NDDS on CC representation of this model.

Only one of the four banks, for this representation, has results which can possibly be interpreted. Banks 1, 2, 3, and 4 have 22, 20, 23, and 24 significant coefficients, respectively. Fourteen, 10, 10, and 11 of these significant coefficients are negative. Only bank 1, with 14 of 22 significant coefficients negative, provides results which might give some insight into the relationship between the short-term component of total savings and other time deposits and treasury securities. For bank 1 it appears that funds from the short-term component do not stay within the treasury security category very long. For the other three banks there are not enough either positive or negative coefficients nor do the coefficients follow a specific enough pattern to allow any interpretation.

The Short Term Component of Total Net Demand, Savings and Other Time Deposits on Treasury Securities. All four banks for this representation have significant lead and lag coefficients. As with all previous representations the significant lag coefficients were anticipated; the significant lead coefficients were not. For an explanation of both the significant lead and lag coefficients see the explanation given in the NDDS on CC representation of this model.

None of the four banks for this representation provide results which can be interpreted. Bank 1 has eight of 19 positive coefficients. Bank 2 has 12 of 22 positive coefficients. Bank 3 has 12 of 22 positive coefficients. Bank 4 has 12 of 24 positive coefficients. None of the significant coefficients for any of the four banks has a specific pattern or sequence which would give some insight into the relationships between the short-term component of total deposits and treasury securities.

Conclusions from the SCAM. The representations for this model provide three discernable results. First, the short-term component of other time deposits provides results which are strictly bank dependent. Regardless of the asset category used, the results from an OTDS representation are different for each of the four banks.

Second, the short-term component of the total categories for the liabilities, i.e., TNSS, TNTS, TSTS and TNSTS, provides consistent results across all banks for a particular asset category. Approximately the same number of coefficients are significant in each representation involving the short-term component of a total liability category. Also, approximately the same number of coefficients have the same sign in each representation involving the short-term component of a total liability category.

Third, all other representations besides those already mentioned appear to be bank dependent. The SAVDS on CC and SAVDS on TS come the closest of the bank dependent representations to having a pattern including more than one bank.

Results of the LCAM

This model like the previous one uses filtered data for the deposits. In this model, it is the long term, i.e., longer than one year, component of each deposit category which is compared with the long term asset categories.

There are 10 representations for this model; five liability categories, including combinations of the initial liability categories, and two asset categories. The five liability categories used are net demand deposits, savings deposits, other time deposits, the total of savings and other time deposits and the total of net demand, savings and other time deposits. The two asset categories used are total loans and other securities, i.e., these are securities other than U. S. treasury securities.

The results for all four banks for each representation of this model are shown in Tables XVIII through XXI. The results for bank one are displayed in Table XVIII. The results for bank two are shown in Table XIX. Bank three's results are presented in Table XX. The results for bank four are shown in Table XXI.

The Long Term Component of Other Time Deposits on Total Loans. All four banks for this representation have both significant lead and lag coefficients. As with previous models, the significant lag coefficients

TABLE XVIII

COEFFICIENTS FOR THE LCAM FOR BANK 1

Time Period	Liability on Asset Category									
	OTDLB1 on TLB1	SAVDLB1 on TLB1	TSTLB1 on TLB1	TNSTLB1 on TLB1	OTDLB1 on OSB1	SAVDLB1 on OSB1	TSTLB1 on OSB1	TNSTLB1 on OSB1	NDDLB1 on TLB1	NDDLB1 on OSB1
11	.03 *	1.5	-.1 *	-.02	.03*	.025*	-.04	0	-.16*	-.05 *
10	.03 *	.2	-.05	-.06	.05*	.02 *	0	-.0125	-.12*	-.05 *
9	.03 *	1.9	-.05	0	.03*	.5 *	.01	-.01	-.1 *	-.03 *
8	.03 *	0	-.07*	.02	.05*	.025*	-.01	.012	-.05*	-.03 *
7	0	-2.1	-.05	-.06	.03*	-.5 *	0	-.02	-.05*	-.03 *
6	.03 *	0	-.07*	0	.05*	.35 *	-.01	0	-.05*	-.04 *
5	.03 *	-.5	-.07*	-.01	.03*	0	-.005	.01	-.02*	0
4	0	-3	-.05	-.06	.03*	-.5 *	-.005	-.01	-.01*	-.025*
3	.03 *	-3.2	-.1 *	-.1 *	.03*	-.65 *	-.01	-.02	-.32*	-.1 *
2	0	-2	-.07*	-.1 *	.02*	-.55 *	-.05	-.03	-.3 *	-.11 *
1	0	4	0	-.1 *	-.05*	.6 *	-.04	.01	.35*	.035*
0	2.48 *	12.2	1.68*	.75*	.7 *	3.1 *	.44*	.188*	1.3 *	.3 *
-1	0	4	.2 *	.15*	-.06*	.5 *	-.005	.0125	.39*	.045*
-2	.03 *	-2	-.39*	0.18*	.05*	-.5 *	-.09*	-.04	-.3 *	-.1 *
-3	.03 *	-2.1	-.21*	-.13*	.05*	-.3 *	-.05	-.03	-.3 *	-.07 *
-4	.03 *	.8	-.07*	-.06	.05*	.48 *	-.005	-.01	-.1 *	-.01 *
-5	.03 *	.8	-.07*	0	.03*	.4 *	-.025	0	-.01*	-.03 *
-6	.03 *	-1.8	-.07*	-.06	.05*	0	-.005	-.02	0	.01 *
-7	.03 *	1.5	-.07*	-.04	.05*	.4 *	-.01	-.015	-.08*	-.02 *
-8	.03 *	-2.1	0	0	.05*	-.24 *	0	.01	-.19*	-.07 *
-9	.03 *	-.8	-.05	-.07*	.07*	0	0	-.015	0	.025*
-10	-.0625*	-.2	-.1 *	-.06	.01*	-.01 *	-.04	-.015	-.11*	-.055*
-11	.03 *	-1.2	-.05	0	.07*	-.02 *	0	.01	-.06*	-.02 *
-12	.03 *	-.7	-.05	-.02	.05*	-.01 *	.01	-.01	-.01*	-.02 *

*Indicates coefficients that are significant at the 5% level.

TABLE XIX

COEFFICIENTS FOR THE LCAM FOR BANK 2

Time Period	Liability on Asset Category: OTDLB2 on TLB2	SAVDLB2 on TLB2	TSTLB2 on TLB2	TNSTLB2 on TLB2	OTDLB2 on OSB2	SAVDLB2 on OSB2	TSTLB2 on OSB2	TNSTLB2 on OSB2	NDDLB2 on TLB2	NDDLB2 on OSB2
11	.2 *	2 *	-.01	-.07	-.01*	-.15*	-.02	-.01	-.15*	-.03 *
10	.25*	1 *	-.19	-.01	0	-.15*	-.02	-.002	-.21*	-.04 *
9	.2 *	1 *	.16	-.05	0	-.15*	.03	-.005	-.28*	-.02 *
8	.2 *	1 *	-.2	-.05	0	0	-.005	-.002	-.09*	-.02 *
7	.2 *	1 *	.2	-.02	0	-.15*	0	-.002	-.21*	-.03 *
6	.25*	2 *	-.23	-.05	0	-.15*	-.07	-.005	-.1 *	-.02 *
5	.2 *	1 *	-.18	-.05	0	-.15*	-.005	-.005	-.2 *	-.02 *
4	.25*	2 *	.2	-.05	0	-.15*	-.005	-.005	-.28*	-.03 *
3	0	-.5*	-.41	-.13	0	-.15*	-.08	-.021	-.3 *	-.07 *
2	1.1 *	9 *	.3	.08	0	-.15*	-.04	-.023	-.08*	-.075*
1	-.48*	-6 *	-.17	0	.02*	0	.04	.03	0	.07 *
0	2.59*	27 *	1.58*	.65*	.59*	5.5 *	.38 *	.16*	1.42*	.37 *
-1	.5 *	2.5*	.54	.24	.03*	0	.07	.05	.05*	.09 *
-2	.2 *	1 *	-.37	-.14	-.01*	-.15*	-.08	-.04	-.4 *	-.075*
-3	.35*	2 *	-.21	-.16	.02*	-.15*	-.04	-.04	-.25*	-.05 *
-4	.25*	1 *	.13	-.06	0	-.15*	-.005	-.01	-.21*	-.04 *
-5	.25*	2 *	-.21	-.01	0	0	-.03	0	-.17*	-.025*
-6	.25*	2 *	.1	.01	0	-.15*	-.005	.002	-.17*	-.02 *
-7	.35*	1 *	-.18	-.01	0	-.15*	-.005	-.005	-.17*	-.02 *
-8	.25*	2 *	0	-.05	0	0	0	-.01	-.08*	-.01 *
-9	.25*	1 *	-.12	0	0	-.15*	-.03	.003	-.21*	-.04 *
-10	.25*	2 *	-.18	-.03	0	-.15*	-.03	-.006	-.1 *	-.02 *
-11	.25*	2 *	0	-.03	0	-.15*	-.005	-.006	-.1 *	-.01 *
-12	.25*	1 *	-.08	-.03	0	0	0	-.006	-.21*	-.03 *

*Indicates coefficients that are significant at the 5% level.

TABLE XX

COEFFICIENTS FOR THE LCAM FOR BANK 3

	Liability on Asset Category									
Time Period	OTDLB3 on TLB3	SAVDLB3 on TLB3	TSTLB3 on TLB3	TNSTLB3 on TLB3	OTDLB3 on OSB3	SAVDLB3 on OSB3	TSTLB3 on OSB3	TNSTLB3 on OSB3	NDDLB3 on TLB3	NDDLB3 on OSB3
11	.08*	1.25*	-.02	-.01	-.005	-.05*	-.008	-.001	0	-.01 *
10	.02*	-.5 *	-.055*	0	-.005	-.05*	0	-.001	.05	-.005
9	-.05*	1.25*	.1 *	-.01	-.015	0	.01	-.001	-.02	-.01 *
8	.35*	-.1 *	-.16 *	-.01	0	-.05*	-.008	-.003	0	-.01 *
7	-.32*	.8 *	.2 *	-.01	-.06 *	-.2 *	-.008	-.01	.05	-.01 *
6	.02*	1.25*	-.23 *	-.01	-.025	-.05*	-.035	-.012	.15 *	.007
5	.21*	-1.4 *	-.04	-.05*	.005	-.15*	-.008	-.008	.15 *	.007
4	.02*	.8 *	.04	-.01	0	-.05*	-.008	-.001	-.06	-.035*
3	.09*	2.5 *	-.2 *	-.01	-.015	0	-.022	-.003	-.31 *	-.075*
2	-.2 *	-3.75*	-.1 *	-.12*	-.027	-.27*	-.03	-.02	-.25 *	-.04 *
1	-.31*	-4 *	-.32 *	-.2 *	-.015	-.2 *	.042	.035	.19 *	.075*
0	1.39*	19 *	1.33 *	.88*	.195 *	2.45*	.158*	.1	1.15 *	.18 *
-1	.1 *	-3.75*	-.1 *	-.1 *	.048 *	-1.25*	.039	.023	.4 *	.065*
-2	-.1 *	-4 *	-.25 *	-.15*	.005	-.4 *	-.024	-.019	-.35 *	-.005
-3	.1 *	2.5 *	-.09 *	-.04	-.015	-.1 *	-.036	-.021	.005	-.05 *
-4	-.1 *	.8 *	0 *	0	-.036 *	-1.25*	-.015	-.01	-.001	-.02 *
-5	-.07*	-.8 *	.07 *	0	-.025	-.1 *	.01	-.003	.15 *	-.01 *
-6	.19*	0	-.1 *	-.01	.02	-.1 *	-.015	-.001	0	-.002
-7	.42*	.8 *	.07 *	0	.05 *	0	-.005	-.001	.004	-.01 *
-8	-.21*	.8 *	0	-.01	-.036 *	-.1 *	-.008	-.003	-.002	-.02 *
-9	.09*	-1.2 *	-.02	.02	-.02	-.2 *	-.008	-.001	.004	-.02 *
-10	.09*	1.25*	-.02	-.04	-.0375*	-.2 *	-.018	-.01	-.002	-.02 *
-11	-.25*	-.8 *	-.05 *	0	-.036 *	-.1 *	-.01	-.001	-.002	-.02 *
-12	.2 *	0	-.05 *	-.02	-.015	-.1 *	0	-.003	.009	-.01 *

*Indicates coefficients that are significant at the 5% level.

TABLE XXI

COEFFICIENTS FOR THE LCAM FOR BANK 4

	Liability on Asset Category									
Time Period	OTDLB4 on TLB4	SAVDLB4 on TLB4	TSTLB4 on TLB4	TNSTLB4 on TLB4	OTDLB4 on OSB4	SAVDLB4 on OSB4	TSTLB4 on OSB4	TNSTLB4 on OSB4	NDDLB4 on TLB4	NDDLB4 on OSB4
11	-.025*	-.4*	-.03	-.02	0	-.045*	-.01	-.003	-.04*	0
10	-.05 *	-.2*	-.03	-.02	-.003*	-.045*	-.005	-.003	-.12*	-.02 *
9	-.025*	-.2*	.11 *	0	-.003*	-.045*	.022	-.002	-.04*	.015*
8	-.05 *	-.2*	.01	0	-.003*	-.045*	.001	-.002	-.12*	-.025*
7	-.05 *	-.4*	-.03	-.01	0	-.045*	-.005	-.002	-.09*	0
6	-.025*	-.2*	-.09 *	0	0	-.045*	-.02	0	0	0
5	-.05 *	-.4*	0	-.01	-.003*	-.045*	0	0	-.15*	-.02 *
4	-.025*	-.2*	-.03	-.01	-.003*	-.045*	-.005	-.002	0	0
3	-.19 *	-1.9*	-.25 *	-.06*	-.003*	-.045*	-.045	-.003	-.3 *	-.01 *
2	.04 *	.5*	-.14 *	.01	-.003*	-.045*	-.024	-.002	-.1 *	0
1	-.1 *	-1.1*	.19 *	.05	-.003*	-.045*	.04	.015	-1.5 *	0
0	1.04 *	10.5*	.55 *	.45*	.225*	2.23 *	.12 *	.095	1.78*	.38 *
-1	-.05 *	-.4*	.2 *	.08*	-.003*	-1 *	.04	.017	.05*	.02 *
-2	-.05 *	-.4*	-.12 *	-.08*	-.003*	-.045*	-.037	-.018	-.11*	-.01 *
-3	-.05 *	-.4*	-.12 *	-.08*	-.003*	-.045*	-.02	-.018	-.07*	-.02 *
-4	-.05 *	-.4*	.04	-.04	-.003*	-.045*	-.001	-.01	-.07*	-.01 *
-5	-.05 *	-.4*	-.11 *	-.03	-.003*	-.045*	-.018	-.008	-.07*	-.01 *
-6	-.025*	-.2*	.11 *	-.02	0	-.045*	.019	-.003	-.07*	-.02 *
-7	-.075*	-.4*	-.04	-.03	-.003*	-.045*	-.01	-.005	-.07*	0
-8	-.025*	-.4*	0	-.04	-.003*	-.045*	0	-.01	-.1 *	-.02 *
-9	-.075*	-.4*	-.08 *	-.03	-.007*	-.045*	-.02	-.008	-.07*	-.02 *
-10	-.05 *	-.4*	-.04	-.05	-.003*	-1 *	-.01	-.01	-.03*	0
-11	-.025*	-.4*	0	-.03	-.003*	-.045*	0	-.008	-.07*	-.01 *
-12	-.075*	-.4*	-.065	-.03	-.003*	-.045*	-.01	-.005	-.1 *	-.01 *

*Indicates coefficients that are significant at the 5% level.

were anticipated and the significant lead coefficients were not. The significant lag coefficients indicate that the funds flowing into a particular long-term asset category at time t depend upon funds which have come into the bank through the long-term component of a liability category in some period t-N. The significant lead coefficients indicate that the funds flowing into a particular long-term asset category at time t are also dependent upon the anticipated inflow of funds from the long-term component of a particular deposit category in period t+N. So it appears that in this representation, funds from past periods and anticipated funds from future periods both have an effect on total loans at time t.

For this representation bank 1 has 18 of 19 significant coefficients positive, while bank 2 has 22 of 23 significant coefficients positive. This indicates that for both banks, the long-term component of other time deposits stays within the total loan category for longer than one week's time. Comparing these results to those of the OTD on TL representation for the LGAM model, shows that both models give the same results, i.e., both the long-term component and the total of the change in other time deposits stay within the total loan category for longer than one week. For banks 1 and 2, there is a strong positive relationship between other time deposits, regardless of how they are measured, and total loans.

The results for this representation for bank 3 show that 12 of 21 significant coefficients are positive. Comparing this representation for this model to the OTD on TL representation for the LGAM model indicates that for bank 3 the long-term component of other time deposits is much more strongly related to total loans than is the total category of other time deposits. No clear interpretation can be given for this representation of the LCAM model because of the near equality of the numbers of positive and negative coefficients and because neither the positive or negative coefficients follow a specific pattern.

Bank 4 has 22 of 24 significant coefficients negative. This implies that funds from the long-term component of other time deposits do not stay within the total loan category for very long or that funds from the long-term component flow into the total loans category on a lagged basis, i.e., they flow from the long term component of OTD into total loans after some positive time period. These results are just opposite of those found for the OTD on TL representation of the LGAM model. For bank 4, the total other time deposit category is positively correlated with total loans while the long-term component of other time deposits is negatively correlated with total loans.

Also, for bank 4 all the coefficients for this representation of the model are significant. This implies that a longer lag might be more appropriate for this representation of this bank for this model.

The Long Term Component of Savings Deposits on Total Loans. For this representation all four banks have both significant lead and lag coefficients. The significant lead coefficients are not anticipated, the significant lag coefficients were anticipated. An explanation for this existence of both significant lead and lag coefficients is given in the preceeding representation of this model.

Banks 1 and 3 for this representation have 13 of 22 and 10 of 22 significant coefficients negative, respectively. Since neither the positive or the negative significant coefficients dominate the other and since neither the positive or the negative significant coefficients exhibit any clear pattern or sequence, no interpretation of this representation for these two banks is given.

Bank 2 has 22 of 23 significant coefficients positive. This indicates that for bank 2 the long-term component of savings deposits stays within the total loan category for longer than one week. Also, it indicates a strong positive correlation between the long-term component of savings deposits and total loans.

Bank 4 has 22 of 24 significant coefficients negative. This implies that for bank 4 funds from the long-term component of other time deposits are negatively correlated with total loans. Also, it implies that funds flowing into the bank through the long-term component of other time deposits do not go immediately into total loans. Or, if they do go immediately into total loans, they do not stay within total loans for a very long period of time.

<u>The Long Term Component of Total Savings and Other Time Deposits on Total Loans</u>. For this representation of the model only three of the banks have both significant lead and lag coefficients. The significant lag coefficients were expected. The significant lead coefficients were not. An explanation for the existence of both the significant lead and lag coefficients is given in the OTDL on TL representation of this model.

Bank 1 has five of seven significant coefficients negative. Even with the majority of coefficients negative, however, total loans will probably be positively correlated with the long-term component for total savings and other time deposits because of a very large, relative to the other coefficients, positive coefficient at time 0. Given the small number of significant coefficients and the dominance of one of the coefficients over the other six, no explanation of the coefficient patterns will be given for bank 1.

Bank 2 has only one significant coefficient which occurs at time 0. Since the coefficient is positive, this indicates that total loans are positively correlated with the long-term component of total savings and other time deposits.

Bank 3 is similar to bank 1 in that the majority, nine, of the bank's 14 significant coefficients are negative. However, the five positive significant coefficients are considerably larger than the nine negative ones. Because of the considerable difference in size between the positive and negative coefficients and because there is no specific pattern for either the positive or negative coefficients, no explanation as to the meaning of the coefficients will be given for bank 3.

For this representation bank 4 has six of 11 significant coefficients negative. Since there is no specific pattern or sequence to the coefficients no explanation is given for the relationship between total loans and the long-term component of other time deposits.

<u>The Long Term Component of Total Net Demand, Savings and Other Time Deposits on Total Loans</u>. For this representation, banks 1 and 3 have both significant lead and lag coefficients. Bank 4 has only significant lead coefficients. The significant lead coefficients were not anticipated. The significant lag coefficients were anticipated. An explanation for the existence of both the significant lead and lag coefficients is given in the OTDL on TL representation of this model.

Banks 1 and 3 have four of seven and four of five significant coefficients negative, respectively. However, the significant coefficients for both banks are dominated by a large positive coefficient at time 0. Since there are so few significant coefficients for each bank and because one coefficients seems to dominate the others, no explanation is given about the relationship between the long-term component of total net demand, savings and other time deposits and total loans.

Bank 2 has only one significant coefficient which occurs at time 0. The coefficient is positive, indicating that for bank 2 total loans are positively correlated with the long-term component of total net demand, savings and other time deposits.

Bank 4 has a significant coefficient at time 0 and three significant lead coefficients. Two of the four significant coefficients are negative. There is a large positive coefficient at time 0 which dominates the other three. As with banks 1 and 3 for this representation, no attempt is made to explain the relationship between the long-term component of total deposits and total loans because of the lack of a specific pattern in the significant coefficients and the small number of significant coefficients.

The Long Term Component of Other Time Deposits on Other Securities. Banks 1, 2, and 3 have significant lead and lag coefficients. Bank 4 has only one significant lead coefficient and no significant lag coefficients. The significant lag coefficients were anticipated. The significant lead coefficients were not. An explanation of both the significant lead and lag coefficients is given in the OTDL on TL representation of this model.

Bank 1, for this representation, has 22 of 24 significant coefficients positive. This indicates a positive correlation between the long-term component of other time deposits and other securities. It also shows that funds from the long-term component of other time deposits go directly into other securities and remain there for a period of time greater than one week. For this bank the majority of the funds provided to other securities from the long-term component of other time deposits came from the current period, i.e., time 0. Comparing these results to the OTD on OS representation of the LGAM shows that it is the long-term component of other time deposits and not the total other time deposits category which relates most closely to other securities for this bank.

Banks 2, 3, and 4 for this representation are similar in that all three have a small number of significant coefficients and all three have large dominate positive coefficients at time 0, i.e., coefficients which are much larger than any of the other coefficients. Banks 2, 3, and 4 have six, five and two significant coefficients, respectively. The large positive coefficient at time 0 for the three banks, indicates that there is a positive correlation between the long-term component of other time deposits and other securities and that the majority of the funds which flow from the long-term component of other time deposits to other securities comes from the current period. Taking these results and comparing them to the OTD on OS representation of the LGAM shows that total other time deposits are also positively correlated to other securities and that the funds flow between the total other time deposit category and other securities is not dominated by one time period, but it fairly evenly spread over several time periods.

The Long Term Component of Savings Deposits on Other Securities. Each of the four banks has both significant lead and lag coefficients. As with previous representations the significant lag coefficients were expected and the significant lead coefficients were not. See the OTDL on TL representation of this model for an explanation of the existence of both significant lead and lag coefficients.

Bank 1 has 11 of 21 significant coefficients positive. Of the 21 significant coefficients, the one in time period 0 is by far the largest. The large positive coefficient in time period 0 does not, however, dominate the remaining significant coefficients as have the larger coefficients in other representations. Since the significant coefficients are almost evenly split between positive and negative and since they follow no specific pattern, no meaningful interpretation of these results for bank 1 exists.

Banks 2 and 4 for this representation produce similar results. Both have all but one of their significant coefficients negative. However, the one positive significant coefficient is larger than the summation of all the significant negative coefficients. This one positive coefficient occurs at time 0 for both banks. These results imply that for both banks a large portion of the funds flowing into the bank at time 0 through the long-term component of savings deposits goes directly into other securities. Funds coming into the bank with a lead or a lag through the long-term component of savings deposits are negatively correlated with other securities and do not go immediately into other securities.

Bank 3 produces results very similar to banks 2 and 4 except that the one positive coefficient at time 0 is not larger than the summation of all the negative significant coefficients. The interpretation of the results is also very similar to banks 2 and 4. Funds from the long term component of savings deposits in the current period go directly into other securities while funds from preceeding and future periods do not go directly into other securities.

The Long Term Component of Total Savings and Other Time Deposits on Other Securities. For this representation the only bank that has a significant lead or lag coefficient is bank 1. All four banks have significant coefficients at time 0, while bank 1 has one significant lead coefficient. Each of the four coefficients which occur at time 0 are positive, indicating that a positive condition exists between the long-term component of total savings and other time deposits and other securities for all four banks. These results also imply that a portion of the funds from the long-term component flows directly into the other securities category.

The Long Term Component of Total Net Demand, Savings and Other Time Deposits on Other Securities. Only banks 1 and 2 for this representation have significant coefficients. Each bank has only one significant coefficient at time 0. Both of the significant coefficients are positive. This indicates that for both banks funds coming into the bank through the long-term component of total deposits go directly into other securities. Noting that total deposits include savings and other time deposits this result could be a reflection of the results reported in the TSTL on OS representation of this model.

All of the coefficients for banks 3 and 4 are insignificant. This indicates that for banks 3 and 4 there is no relationship between the long-term component of total deposits and other securities.

The Long Term Component of Net Demand Deposits on Total Loans. All four banks for this representation have both significant lead and lag coefficients. The significant lag coefficients were anticipated. The significant lead coefficients were not. As with previous representations, the explanation for both significant lead and lag coefficients is given in the OTDL on TL representation of this model.

Banks 1 and 2 for this representation provide similar results. Bank 1 has 18 of 22 significant coefficients negative and bank 2 has 21 of 23 significant coefficients negative. The results for both banks indicate that the long-term component of net demand deposits is negatively correlated with total loans. This implies that funds from the long-term component do not go immediately into the total loans category; or if they do go immediately into total loans they do not remain within the total loan category for more than one week's time.

Bank 3 has six of nine significant coefficients positive. This indicates that for this bank the long-term component of net demand deposits is positively correlated with total loans. The positive condition indicates that some of the funds flowing into the bank through the long-term component go directly into total loans and remain there for a significant period of time.

Bank 4 has 19 of 22 significant coefficients negative. Bank 4 is differentiated from banks 1 and 2 in that at time 0 bank 4 has a very large positive coefficient. This one coefficient is larger than the summation of all the negative coefficients for this bank. These results imply three things. First, funds coming into the bank at time 0 from the long-term component of net demand deposits go directly into total loans. Second, that funds which have come into the bank through the long-term component in previous periods are flowing out of total loans. Third, funds from future periods are not expected to go directly into total loans.

The Long Term Component of Net Demand Deposits on Other Securities. Each of the four banks for this representation have both significant lead and lag coefficients. The significant lag coefficients were anticipated. The significant lead coefficients were not anticipated. An explanation for the existence of the significant lead and lag coefficients is given in the OTDL on TL representation of this model.

Banks 1, 2, and 3 produce similar results. Bank 1 has 19 of 23 significant coefficients negative. Bank 2 has 21 of 24 significant coefficients negative. Bank 3 has nine of 12 significant coefficients negative. These results indicate a negative correlation between the long-term component of net demand deposits and other securities. They also indicate that for these three banks, funds from the long term component go directly into other securities but do not stay within the other securities category for more than two weeks.

Bank 4 has 13 of 16 significant coefficients negative. It does, however, have one large positive coefficient at time 0. The coefficient at time 0 is larger than the summation of all of the 13 negative coefficients. The results for the bank can be interpreted the same as the results for banks 1, 2, and 3.

Conclusions from the LCAM. SAVDL on TLL is the only representation of this model which is bank dependent, i.e., the results for this representation are different for each bank. All of the other representations have similar results across some of the banks. In some cases the same results appear in more than one representation. This observation holds true for those representations which use some form of total liabilities, i.e., a summation of the individual liability categories, as the source of funds.

Summary for the Heuristic Stochastic Models

The results from the five heuristic stochastic models yield the following:

A. It was originally hypothesized that the five models would have no significant lead coefficients. The results for all five of the models contain significant lead coefficients. The handling of the lead coefficients will be explained in the next section of this chapter.

B. It was originally hypothesized for all five models that no lagged relationship existed between the dependent and independent variables. The results for all five models contain significant lag coefficients for almost every representation. All of the significant lag coefficients are for 12 periods or less. This result answers the first question posed in Chapter III. Is there a lagged relationship between deposit sources and asset uses, and if so, what is that relationship?

C. It was originally hypothesized that the bank asset adjustment process would follow one of the five relationships set forth in the five models. To determine which of the five models, i.e., relationships, best specifies the asset adjustment process will require further work. This additional work is outlined in Chapter IV and explained in the next section of this chapter.

The following, however, can be determined from the results examined so far. Given the definition of funds as cash, i.e., coin and currency, it is obvious that the banks do not create a pool of cash from which monies are drawn for investment purposes. This eliminates the SFM as a viable alternative for explaining the bank asset adjustment process. Since the SFM is eliminated, equations (7) and (14) in Chapter III can not exist. This result implies that the SGAM and the SCAM will be the models which best explain the adjustments in the banks' short-term asset categories. This further implies that the LGAM and/or the LCAM will be the models which best explain the adjustments in the banks' long-term asset categories. The next section of this chapter will present the results which indicate which is the better of the two long-term models.

The Root Mean Square Error for The Heuristic and Optimization Models

The purpose of this study is to compare the predictive abilities of three different models of the adjustment process for a bank's asset portfolio. The best way to compare the predictive abilities for different models is to measure how closely the predicted values for each model came to the actual values the model is trying to predict. An appropriate measure for comparing predicted to actual values is the Root Mean Square Error (RMSE).[5]

Since the RMSE uses the squared difference between the actual and predicted values, the lower the RMSE the better. Therefore, whenever

[5] This measure is defined and explained in Chapter IV.

a reference is made to the "best" representation for a particular asset category, the term "best" means that representation with the lowest RMSE.

The RMSE for the Heuristic Models

In determining the predicted values for the Heuristic models for all of the banks, the significant lead coefficients in each representation are omitted because at time t the bank does not know the amount of deposits it will have in a particular deposit category at time t+N. Thus, even though the coefficients are known the bank could not know the change in any of the deposit categories in any of the t+N periods. The bank can know that the change in a particular asset category will depend upon changes in future deposit categories, but it is improbable that the bank could predict with any degree of accuracy the precise effect the future changes in deposits will have on the current change in assets. For this reason the significant lead coefficients were omitted in determining the predicted changes in the asset categories for the Heuristic models.

For each bank, i.e., 1, 2, 3, and 4, and for each asset category, i.e., coin and currency, treasury securities, other securities and total loans, several representations of each bank asset category combination were studied.[6] The RMSEs for each representation of each model are presented by bank and asset category in Tables XXIII through XXXVIII. The results of the Heuristic models for bank 1 are in Tables XXIII through

[6]A list of representations by asset category is presented in Table XXII. The asset categories and their representations are the same for each bank.

TABLE XXII

A LISTING OF THE REPRESENTATIONS FOR THE ASSET CATEGORIES

Coin and Currency	Treasury Securities	Other Securities	Total Loans
1 NDD on CC	1 NDD on TS	1 OTD on OS	1 OTD on TL
2 SAVD on CC	2 SAVD on TS	2 TST on OS	2 TST on TL
3 TNS on CC	3 TNS on TS	3 NDDL on OS	3 NDDL on TL
4 NDDS on CC	4 NDDS on TS	4 SAVDL on OS	4 SAVDL on TL
5 SAVDS on CC	5 SAVDS on TS	5 OTDL on OS	5 OTDL on TL
6 OTDS on CC	6 OTDS on TS	6 TSTL on OS	6 TSTL on TL
7 TNSS on CC	7 TNSS on TS	7 TNSTL on OS	7 TNSTL on TL
8 TNTS on CC	8 TSTS on TS		
9 TNSTS on CC	9 TNSTS on TS		

TABLE XXIII

ASSET CATEGORY: COIN AND CURRENCY, BANK 1

Representation Number	Name	RMSE
1	NDD on CC	1581
2	SAVD on CC	1542*
3	TNS on CC	1581
4	NDDS on CC	2490
5	SAVDS on CC	8036
6	OTDS on CC	1785
7	TNSS on CC	1930
8	TNTS on CC	3910
9	TNSTS on CC	1779

*Lowest RMSE.

TABLE XXIV

ASSET CATEGORY: TREASURY SECURITIES, BANK 1

Representation Number	Name	RMSE
1	NDD on TS	23669
2	SAVD on TS	23473
3	TNS on TS	23362
4	NDDS on TS	30440
5	SAVDS on TS	35512
6	OTDS on TS	20650*
7	TNSS on TS	24903
8	TSTS on TS	50977
9	TNSTS on TS	29309

*Lowest RMSE.

TABLE XXV

ASSET CATEGORY: OTHER SECURITIES, BANK 1

Representation Number	Name	RMSE
1	OTD on OS	18193*
2	TST on OS	19429
3	NDDL on OS	887906
4	SAVDL on OS	957793
5	OTDL on OS	4473527
6	TSTL on OS	3450926
7	TNSTL on OS	810295

*Lowest RMSE.

TABLE XXVI

ASSET CATEGORY: TOTAL LOANS, BANK 1

Representation Number	Name	RMSE
1	OTD on TL	22461
2	TST on TL	20842*
3	NDDL on TL	3878645
4	SAVDL on TL	3449058
5	OTDL on TL	5149887
6	TSTL on TL	4420080
7	TNSTL on TL	3999833

*Lowest RMSE.

XXVI. The results of the Heuristic models for bank 2 are in Tables XXVII through XXX. The RMSE results for bank 3 can be found in Tables XXXI through XXXIV. The results of the Heuristic models for bank 4 are in Tables XXXV through XXXVIII.

The RMSEs for the Heuristic Models of Bank 1. For bank 1, the RMSEs for the various representations of the SGAM and SCAM for the coin and currency category are shown in Table XXIII. In Table XXIII the first three representations are of the SGAM and the last six representations are of the SCAM. For the coin and currency category for bank 1, it is an SGAM representation, SAVD on CC, which yields the lowest RMSE. This implies that for the coin and currency category of bank 1 a form of the SGAM is the best model. Even though this form of the SGAM yields the lowest RMSE for this bank and asset category, it is still not an accurate predictor of the change in coin and currency. This is because the RMSE for this representation is large relative to the actual changes in coin and currency for bank 1.

The RMSEs for the treasury security category of bank 1 are displayed in Table XXIV. The first three representations are forms of the SGAM and the last six are forms of the SCAM. For the treasury security category for bank 1 it is an SCAM representation, OTDS on TS, which yields the minimum RMSE. These results indicate that for this asset category and bank the short term component of other time deposits, a form of the SCAM, is the best representation. The RMSE of this representation is also large relative to the actual changes in treasury securities for this bank.

The RMSEs for the other securities category for bank 1 are shown in Table XXV. In this case, the first two representations are forms of the

LGAM and the last five are forms of the LCAM. For this asset category it is an LGAM representation, OTD on OS, which gives the lowest RMSE. These results indicate that for this bank and asset category it is a form of the LGAM which is the best representation. This representation provides a better estimate of the actual changes in other securities than did the representations with the minimum RMSE for coin and currency and treasury securities.

Finally, for bank 1, the RMSEs for the asset category total loans are shown in Table XXVI. The first two representations are of the LGAM and the last five are of the LCAM. For total loans in bank 1, it is an LGAM representation, TST on TL, which provides the smallest RMSE. The RMSEs show that for this bank and asset category that a form of the LGAM is the best representation. As with other securities, the representation providing the minimum RMSE for the total loan category provides a better estimate of the actual total loans held by this bank than did the best representations with the coin and currency and treasury security categories.

In summation for bank 1, two points can be made. First, three of the four best representations are a form of the group allocation models, i.e., those for coin and currency, other securities and total loans. The implication is that bank 1 tends to allocate funds to various asset categories more by the total amount of change in a particular deposit category than by a change in the short- or long-run component of a particular deposit category. Second, the long-term asset categories, i.e., other securities and total loans, are more accurately predicted for this bank than are the short-term categories, i.e., coin and currency and treasury securities.

The RMSEs for the Heuristic Models of Bank 2. The RMSEs for the coin and currency category of bank 2 are shown in Table XXVII. The first three representations are of the SGAM and the last six are of the SCAM. For this asset category and bank it is an SCAM representation, NDDS on CC, which gives the minimum RMSE. This means that for this asset category and bank a form of the SCAM is the best model. As with the same asset category for bank 1, this model did not predict very accurately the actual changes in coin and currency for this bank.

For the treasury securities category of bank 2, the RMSEs are presented in Table XXVIII. The first three representations in the table are forms of the SGAM while the last six are forms of the SCAM. For this asset category and bank it is an SCAM representation, TSTS on TS, which has the lowest RMSE. These results indicate that for this bank and asset category, it is a form of the SCAM that is the best representation. This model does predict more accurately for this bank than does the model with the minimum RMSE for this asset category for bank 1.

The RMSEs for the other securities category of bank 2 are displayed in Table XXIX. The first two representations are forms of the LGAM while the next five are representations of the LCAM. It is an LGAM representation which has the smallest RMSE for the bank and asset category. These results indicate that for this bank and asset category a form of the LGAM, OTD on OS, is the best representation. This model, with the lowest RMSE, is a more accurate predictor of the actual change in other securities than were the models with the lowest RMSE for coin and currency and treasury securities.

The RMSEs for the total loan category for bank 2 are shown in Table XXX. The first two representations are of the LGAM and the last

TABLE XXVII

ASSET CATEGORY: COIN AND CURRENCY, BANK 2

Representation Number	Name	RMSE
1	NDD on CC	1266
2	SAVD on CC	1158
3	TNS on CC	43279
4	NDDS on CC	1067*
5	SAVDS on CC	9095
6	OTDS on CC	5139
7	TNSS on CC	4245
8	TNTS on CC	7471
9	TNSTS on CC	2137

*Lowest RMSE.

TABLE XXVIII

ASSET CATEGORY: TREASURY SECURITIES, BANK 2

Representation Number	Name	RMSE
1	NDD on TS	55810
2	SAVD on TS	12790
3	TNS on TS	217562
4	NDDS on TS	10746
5	SAVDS on TS	59186
6	OTDS on TS	31311
7	TNSS on TS	15813
8	TSTS on TS	9869*
9	TNSTS on TS	10472

*Lowest RMSE.

TABLE XXIX

ASSET CATEGORY: OTHER SECURITIES, BANK 2

Representation Number	Name	RMSE
1	OTD on OS	12479*
2	TST on OS	152680
3	NDDL on OS	1017612
4	SAVDL on OS	194751
5	OTDL on OS	1224382
6	TSTL on OS	789388
7	TNSTL on OS	657690

*Lowest RMSE.

TABLE XXX

ASSET CATEGORY: TOTAL LOANS, BANK 2

Representation Number	Name	RMSE
1	OTD on TL	56075
2	TST on TL	1375581
3	NDDL on TL	1594191
4	SAVDL on TL	22953
5	OTDL on TL	4523273
6	TSTL on TL	3299205
7	TNSTL on TL	2706679

*Lowest RMSE.

five are of the LCAM. It is an LCAM representation, SAVDL on TL, which gives the minimum RMSE for this asset category and bank. This indicates that a form of the LCAM is the best representation for total loans for this bank. As with bank 1, this model is a more accurate predictor of total loans than are the models with the lowest RMSEs for the coin and currency and treasury securities categories.

In summation for bank 2, two points can again be made. First, three of the four best representations are a form of the component allocation model, i.e., those for coin and currency, treasury securities and total loans. The implication is that bank 2 tends to allocate funds to various asset categories based upon the change in the short-term or long-term component of a particular deposit category. Second, as with bank 1, the long-term asset categories, i.e., other securities and total loans, are more accurately predicted for this bank than are the short-term asset categories, i.e., coin and currency and treasury securities.

The RMSEs for the Heuristic Model of Bank 3. For the coin and currency category of bank 3, RMSEs are presented in Table XXXI. The first three representations are of the SGAM and the last six are of the SCAM. For this bank and asset category it is an SCAM representation, TNSTS on CC, which has the smallest RMSE. This implies that for this bank and asset category a form of the SCAM is the best model. As with the previous two banks, this model was not a very accurate predictor of the change in the coin and currency account.

The RMSEs for the treasury security category of bank 3 are shown in Table XXXII. The first three representations are of the SGAM and the

TABLE XXXI

ASSET CATEGORY: COIN AND CURRENCY, BANK 3

Representation Number	Name	RMSE
1	NDD on CC	821
2	SAVD on CC	863
3	TNS on CC	4923
4	NDDS on CC	862
5	SAVDS on CC	991
6	OTDS on CC	784
7	TNSS on CC	786
8	TNTS on CC	882
9	TNSTS on CC	769*

*Lowest RMSE.

TABLE XXXII

ASSET CATEGORY: TREASURY SECURITIES, BANK 3

Representation Number	Name	RMSE
1	NDD on TS	7688
2	SAVD on TS	8380
3	TNS on TS	37815
4	NDDS on TS	7973
5	SAVDS on TS	9836
6	OTDS on TS	30265
7	TNSS on TS	11960
8	TSTS on TS	11478
9	TNSTS on TS	7653*

*Lowest RMSE.

TABLE XXXIII

ASSET CATEGORY: OTHER SECURITIES, BANK 3

Representation Number	Name	RMSE
1	OTD on OS	11010
2	TST on OS	28717
3	NDDL on OS	63564
4	SAVDL on OS	66241
5	OTDL on OS	16586
6	TSTL on OS	42408
7	TNSTL on OS	11009*

*Lowest RMSE.

TABLE XXXIV

ASSET CATEGORY: TOTAL LOANS, BANK 3

Representation Number	Name	RMSE
1	OTD on TL	1490*
2	TST on TL	1490*
3	NDDL on TL	372500
4	SAVDL on TL	84162
5	OTDL on TL	158676
6	TSTL on TL	301695
7	TNSTL on TL	301621

*Lowest RMSE.

last six representations are of the SCAM. The findings indicate that it is an SCAM, TNSTS on TS, which yields the lowest RMSE. This means that for this bank and asset category, a representation of the SCAM is the best model. For this bank this model appears to be the least accurate predictor of the actual values of the four asset categories predicted.

The RMSEs for the other securities category for this bank are displayed in Table XXXIII. The first two representations are of the LGAM, the last five are of the LCAM. For this bank and asset category it is an LCAM representation, TNSTL on OS, which has the minimum RMSE. This means that for this bank and asset category a form of the LCAM is the best model. This model, while not extremely accurate at predicting the actual change in other securities, is more accurate than the models for the coin and currency and treasury security categories.

The RMSEs for the total loan category for this bank are shown in Table XXXIV. The first two representations are for the LGAM and the last five are for the LCAM. Two LGAM representations for this model, OTD on TL and TST on TL, given the lowest RMSE for this bank and asset category. These results indicate that for this bank and asset category two forms of the LGAM are the best models. These two forms of the LGAM give the most accurate predictions of the actual changes in this asset category relative to the other models' predictions for the changes in the other three asset categories of bank 3.

In summation for bank 3, three results need to be emphasized. First, as with the previous two banks, the long-term asset categories, i.e., total loans and other securities, are more accurately predicted than are the short-term categories, i.e., coin and currency and treasury securities.

Second, three of the four best representations are forms of the component allocation model. These are coin and currency, treasury securities, and other securities.[7] This indicates that bank 3 tends to allocate funds from its deposit categories on the basis of the long- and short-term components of those deposit categories. Third, the deposit category whose short- or long-term component is the best predictor in all three of the above cases is total net demand, savings and time deposits. Apparently bank 3 allocated funds to asset categories not from specific deposit categories but from the components of their total deposits.

The RMSEs for the Heuristic Models of Bank 4. The RMSEs for the coin and currency category for this bank are shown in Table XXXV. The first three representations are of the SGAM, the last six representations are for the SCAM. The findings indicate that it is an SGAM representation, NDD on CC, which has the lowest RMSE. This model predicts the change in coin and currency more accurately than any of the models for coin and currency for the preceeding three banks. This particular representation for this bank is still only moderately accurate in predicting the actual changes in coin and currency.

The RMSEs for the treasury security category are presented in Table XXXVI. The first three representations are of the SGAM and the last six are of the SCAM. For this bank and asset category it is an SGAM, SAVD on TS, which has the lowest RMSE. This means that for this asset category

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[7]There is a very close second best representation. This second best representation is an LGAM, OTD on OS. This implies that this bank could be using either the long-term component of total deposits or the OTD category to predict total loans.

TABLE XXXV

ASSET CATEGORY: COIN AND CURRENCY, BANK 4

Representation Number	Name	RMSE
1	NDD on CC	339*
2	SAVD on CC	388
3	TNS on CC	594
4	NDDS on CC	563
5	SAVDS on CC	1861
6	OTDS on CC	362
7	TNSS on CC	374
8	TNTS on CC	8135
9	TNSTS on CC	930

*Lowest RMSE.

TABLE XXXVI

ASSET CATEGORY: TREASURY SECURITIES, BANK 4

Representation Number	Name	RMSE
1	NDD on TS	1923
2	SAVD on TS	1853*
3	TNS on TS	53914
4	NDDS on TS	7621
5	SAVDS on TS	13325
6	OTDS on TS	6455
7	TNSS on TS	46374
8	TSTS on TS	5532
9	TNSTS on TS	6377

*Lowest RMSE.

TABLE XXXVII

ASSET CATEGORY: OTHER SECURITIES, BANK 4

Representation Number	Name	RMSE
1	OTD on OS	1541
2	TST on OS	41660
3	NDDL on OS	88246
4	SAVDL on OS	89829
5	OTDL on OS	86342
6	TSTL on OS	43163
7	TNSTL on OS	1538*

*Lowest RMSE.

TABLE XXXVIII

ASSET CATEGORY: TOTAL LOANS, BANK 4

Representation Number	Name	RMSE
1	OTD on TL	2361*
2	TST on TL	286938
3	NDDL on TL	440199
4	SAVDL on TL	451801
5	OTDL on TL	437688
6	TSTL on TL	286418
7	TNSTL on TL	290475

*Lowest RMSE.

and bank a form of the SGAM is the best model. As with all three other banks, this model was not an accurate predictor of the change in treasury securities.

The other securities category for bank 4 is shown in Table XXXVII. The first two representations are of the LGAM, the last five are of the LCAM. The results indicate that it is an LCAM, TNSTL on OS, which provides the lowest RMSE. This means that for this bank and asset category the LCAM appears to be the best model. While still a more accurate predictor than the models for the short-term asset categories, this model is also the most inaccurate for the four banks at predicting the change in other securities.

The RMSEs for the total loan category of bank 4 are displayed in Table XXXVIII. The first two representations are of the LGAM while the last five are for the LCAM. For this bank and asset category it is an LGAM, OTD, on TL, which gives the minimum RMSE. This result means that it is a form of the LGAM which is the best model for this bank and asset category. As with the previous banks, this model for predicting the change in total loans is more accurate than the models for predicting the changes in the coin and currency and treasury securities categories for bank 4.

For bank 4, two conclusions can be stated. First, three of the four asset categories, i.e., coin and currency, treasury securities and total loans, have a form of the group allocation model as their best model. This implies that for this bank, funds are allocated to the asset categories on the basis of the total amount of change in a particular deposit category. Second, as with the previous three banks, the models for the long-term asset categories, i.e., other securities and total loans, were better predictors of the actual changes in the asset categories than were the models for the short-term asset categories, i.e., coin and currency and treasury securities.

The RMSEs for the Optimization Models

The results for the two optimization models are presented in this section; first the results from the linear programming model and then the results from the quadratic programming model.

The RMSEs for the Linear Programming Model. The RMSEs for the linear programming model are shown in Tables XXIX and XL. The first table displays the results by asset category for banks 1 and 2. The second table presents the results by asset category for banks 3 and 4. As with the Heuristic models, the linear programming model gives more accurate predictions for the long-term, i.e., other securities and total loans, asset categories than for the short-term categories. The one exception is the total loans category for bank 2. The linear programming model gives the least accurate predictions for this bank and asset category. Over all, the linear programming model is not a very accurate predictor of bank behavior.

The RMSEs for the Quadratic Programming Model. The RMSEs for the quadratic programming model are shown in Tables XLI and XLII. Table XLI displays the results by asset category for banks 1 and 2. Table XLI displays the results by asset category for banks 3 and 4. The results for the quadratic programming model are different from the results of the Heuristic and linear programming models. The quadratic programming model yields the best results for the short-term asset categories, i.e.,

TABLE XXXIX

RMSE BY ASSET CATEGORY AND BANK FOR THE LINEAR PROGRAMMING MODEL, BANKS 1 AND 2

Category	RMSE
Bank 1:	
Coin and Currency	1577
Treasury Securities	24980
Other Securities	16800
Total Loans	24600
Bank 2:	
Coin and Currency	1039
Treasury Securities	24000
Other Securities	15000
Total Loans	64200

TABLE XL

RMSE BY ASSET CATEGORY AND BANK FOR THE LINEAR PROGRAMMING MODEL, BANKS 3 AND 4

Category	RMSE
Bank 3:	
Coin and Currency	1034
Treasury Securities	7880
Other Securities	10796
Total Loans	2086
Bank 4:	
Coin and Currency	343
Treasury Securities	3472
Other Securities	1742
Total Loans	2563

TABLE XLI

RMSE BY ASSET CATEGORY AND BANK FOR THE QUADRATIC PROGRAMMING MODEL, BANKS 1 AND 2

Category	RMSE
Bank 1:	
Coin and Currency	1527
Treasury Securities	23315
Other Securities	14650
Total Loans	50524
Bank 2:	
Coin and Currency	1067
Treasury Securities	10745
Other Securities	12998
Total Loans	80869

TABLE XLII

RMSE BY ASSET CATEGORY AND BANK FOR THE QUADRATIC PROGRAMMING MODEL, BANKS 3 AND 4

Category	RMSE
Bank 3:	
Coin and Currency	862
Treasury Securities	8112
Other Securities	11028
Total Loans	2489
Bank 4:	
Coin and Currency	362
Treasury Securities	5728
Other Securities	1538
Total Loans	2301

coin and currency and treasury securities, and the other securities category. This holds true for banks 1, 2, and 3. Bank 4 is the only exception, and this is because the quadratic model predicts so poorly for the treasury securities category.

The quadratic programming model is the least accurate predictor of the total loans category for banks 1, 2, and 3. This result differs markedly from the Heuristic and linear programming models. This model is, however, the best predictor of total loans for bank 4. The results for this model, as with the previous models, are bank and asset category dependent. The quadratic programming model does appear to best predict the short-term asset categories, but it is a very poor predictor of the total loans category.

CHAPTER VI

SUMMARY AND CONCLUSIONS

The purpose of this study is to compare the predictive abilities of different, i.e., heuristic and optimization, models of the adjustment process for a bank's asset portfolio. The research revealed that the heuristic models were the most accurate predictors for all four bank's portfolio adjustment processes. The analysis also indicated that for the four banks studied the way in which funds flow into particular asset categories is very much bank and asset category dependent. This means that for these four banks there is not a uniform way in which funds flow into particular asset categories. There is not even a uniform flow within a particular bank. These results indicate that there is no one correct approach, i.e., asset allocation, pool-of-funds, etc., which describes how funds flow into a bank's asset categories.

The nature of this study is descriptive, not normative. It presents the behavior of four banks as analyzed by the models used. The results of this study do not mean that all banks behave in a manner similar to the four studied. Nor are the models used to study the banks all inclusive. It is hoped that the results of this research, while not all encompassing, will provide additional emphasis for further study into bank behavior.

Overview of the Study

The models of bank behavior and their underlying ideas are presented in Chapters I and II. None of the studies presented in Chapter II, however, have compared the predictive abilities of the different models of bank behavior. Based on a desire to compare the predictive abilities of the various models of bank behavior, the following null and alternative hypotheses were formulated.

Hypothesis No. 1

H_0: Funds which flow into the bank as deposits with a long-term maturity will not be placed into asset categories which have a long-term maturity.

H_1: Funds which flow into the bank as deposits with a long-term maturity will be placed into asset categories which have a long-term maturity.

Hypothesis No. 2

H_0: Funds which flow into the bank as deposits with a short-term maturity will not be placed into asset categories which have a short-term maturity.

H_1: Funds which flow into the bank as deposits with a short-term maturity will be placed into asset categories which have a short-term maturity.

Hypothesis No. 3

H_0: All funds flowing into the bank as deposits will be placed into asset categories which have a short-term maturity.

H_1: All funds flowing into the bank as deposits will not be placed into asset categories which have a short-term maturity.

Hypothesis No. 4

H_0: The transitory component of the short-term deposits and/or the transitory component of the long-term deposits will not be allocated to asset categories which have a short-term maturity.

H_1: The transitory component of the short-term deposits and/or the transitory component of the long-term deposits will be allocated to asset categories which have a short-term maturity.

Hypothesis No. 5

H_0: The permanent component of the short-term deposits and/or the permanent component of the long-term deposits will not be allocated to asset categories which have a long-term maturity.

H_1: The permanent component of the short-term deposits and/or the permanent component of the long-term deposits will be allocated to asset categories which have a long-term maturity.

Hypothesis No. 6

H_0: A bank will adjust its asset portfolio in such a way as to maximize bank profits. It will make the adjustments restricted by legal, regulatory and managerial constraints.

H_1: A bank will <u>not</u> adjust its asset portfolio in such a way as to maximize bank profits. It will make the adjustments restricted by legal, regulatory and managerial constraints.

Hypothesis No. 7

H_0: A bank adjusts its asset portfolio in such a way as to minimize its risk for a given level of return or maximize its return for a given level of risk.

H_1: A bank will <u>not</u> adjust its asset portfolio in such a way as to minimize its risk for a given level of return or maximize its return for a given level of risk.

The methodology of this research was divided into three groups according to the model of bank behavior, i.e., heuristic, linear programming, or quadratic programming, being used. The methodology for the heuristic models is presented first, followed by the methodology for the linear programming and quadratic programming models, respectively.

The methodology for the heuristic models consisted of first using spectral analysis to determine the appropriate lead-lag structure. This was accomplished by comparing gain and phase diagrams for known lead-lag relationships to the gain and phase diagrams found in this study. After determining the appropriate lead-lag structure, spectral analysis was again used to filter the funds inflows. This allowed the funds inflows to be divided into their permanent and transitory components for each deposit category. Using the filtered and non-filtered data, depending upon the heuristic model being used, Hannan's inefficient method of time series analysis was used to obtain the regression coefficients. The regression coefficients were then used to obtain the predicted portfolio values for each bank and asset category. The predicted portfolios and the actual portfolios were then used to calculate the Root Mean Square Errors for each bank and asset category.

The methodology for the linear programming model was a bit simplier. Using the appropriate constraints, the linear programming model was used to generate the percentage of total assets which should be in each asset category. The percentages for each bank were then multiplied by the total assets for each bank to give the predicted asset portfolios for each bank. Using the predicted and actual asset portfolios, the RMSEs for each bank and asset category were calculated.

The methodology for the quadratic programming was exactly the same as that for the linear programming. Quadratic programming was used to generate a frontier of minimum risk for a given level of return portfolios. The variance of the returns for each bank's total asset portfolio was calculated and the portfolio on the efficient frontier with the closest level of risk was chosen as the optimum risk/return portfolio for the bank. This optimum portfolio gave the percentage of total assets which should be in each asset category. The percentages for each bank were then multiplied by the total assets for each bank to get the predicted amounts for each asset category. As before, using the predicted and actual amounts for each asset category, the RMSEs for each bank were calculated.

The Research Results

The Results of the Predictive Abilities of the Heuristic, Linear Programming and Quadratic Programming Models

Table XLIII presents the RMSEs for each bank for each model. The heuristic models yield the lowest RMSEs for all four banks using all asset categories. The linear programming model gives the second lowest RMSEs for all four banks. The quadratic programming model yields the largest RMSEs for all four banks.

These results indicate that the heuristic models are the most accurate predictors of all four bank's asset portfolio adjustment process. The linear programming model is the second most accurate model, while the quadratic programming model is the least accurate.

Tables XLIV through XLVII show the RMSEs by bank by model for each asset category. Table XLIV indicates the results for the coin and currency category. The results in Table XLIV show that the heuristic model yields the lowest RMSEs for banks 3 and 4. These results also indicate that both the linear and the quadratic programming models provide the minimum RMSEs for one bank each, i.e., banks 2 and 1, respectively. Obviously, which model is the best at predicting the banks' coin and currency is not clear cut.

Table XLV presents the outcome for the treasury securities category. The heuristic models present the lowest RMSEs for all four banks for this asset category. The quadratic programming model presents the second lowest RMSEs for banks 1 and 2, while the linear programming model provides the second lowest RMSEs for banks 3 and 4. Conclusively, the

TABLE XLIII

TOTAL ASSETS PREDICTION (RMSEs FOR ALL FOUR ASSET CATEGORIES BY MODEL)

Bank	Model LP	TS	QP
1	18835	17278*	28780
2	35079	13974*	41308
3	6783	6756*	6971
4	2334	1695*	3186
		Using the best representation for each asset category	

*Lowest RMSE.

TABLE XLIV

RMSE BY MODEL, COIN AND CURRENCY

Bank	Model LP	TS	QP
1	1577	1542	1527*
2	1039*	1067	1067
3	1034	769*	862
4	343	339*	362

*Lowest RMSE.

TABLE XLV

RMSE BY MODEL, TREASURY SECURITIES

Bank	Model LP	TS	QP
1	24980	20650*	23315
2	24000	9869*	10745
3	7880	7653*	8112
4	3472	1853*	5728

*Lowest RMSE.

TABLE XLVI

RMSE BY MODEL, OTHER SECURITIES

Bank	Model LP	TS	QP
1	16800	18193	14650*
2	15000	12479*	12998
3	10796*	11009	11028
4	1742	1538*	1538*

*Lowest RMSE.

heuristic models are the best predictors of the treasury securities held by all four banks.

Table XLVI shows the results for the other securities asset category. As with the coin and currency category, the results of this category are mixed. For banks 2 and 4 the heuristic models provide the smallest RMSEs. The linear programming model yields the lowest RMSE for bank 3. The quadratic programming model provides the lowest RMSEs for banks 1 and 4. The heuristic and the quadratic programming models provided the exact same RMSE for this category for bank 4.

Table XLVII gives the results for the total loans category. The heuristic models have the lowest RMSEs for banks 1, 2, and 3, and the second lowest RMSE, by a very small margin, for bank 4. The linear programming model has the second lowest RMSEs for banks 1, 2, and 3. The quadratic programming model has the lowest RMSE for bank 4. The results for total loans are fairly clear. The heuristic models are the best predictors of the total loans category. The linear programming model is the second best predictor for this asset category. And considering the magnitude of the RMSEs, the quadratic programming model is by far the worst predictor of total loans.

The heuristic models are the best predictors for the treasury securities and total loans categories. While the results for coin and currency and other securities are mixed, the heuristic models have the lowest RMSEs for two of the four banks. Therefore, it is not unexpected that the heuristic models should provide the lowest RMSEs for all asset categories for all four banks.

Using the RMSE as a measure of predictability indicates that none of the four banks adjust their asset portfolios according to hypotheses six and seven in Chapter III. The results indicate that the null hypothesis for hypotheses six and seven must be rejected and the alternative hypotheses accepted, i.e., that the banks do <u>not</u> adjust their asset portfolios in order to maximize profits or to minimize a risk per unit of return relationship. These results lead to the conclusion that the banks adjust their asset portfolios according to the behavior postulated by one or more of the first five hypotheses, i.e., those relating to the heuristic models, presented in Chapter III.

TABLE XLVII

RMSE BY MODEL, TOTAL LOANS

Bank	Model LP	TS	QP
1	24600	20842*	50524
2	64200	22953*	80869
3	2086	1490*	2489
4	2563	2361	2301*

*Lowest RMSE.

The Implications of the Results of the Heuristic Models

Tables XLVIII through LII show those heuristic models by bank and asset category which yielded the lowest RMSEs. Tables XLVIII through LI indicate the best heuristic models for each bank by asset category. Table LII shows the best heuristic models by asset category for all four banks.

TABLE XLVIII

LOWEST ROOT MEAN SQUARE ERROR
REPRESENTATION, BANK 1

Category	Representation of Model With the Lowest RMSE
Coin and Currency	SAVD on CC
Treasury Securities	OTDS on TS
Other Securities	OTD on OS
Total Loans	TST on TL

TABLE XLIX

LOWEST ROOT MEAN SQUARE ERROR
REPRESENTATION, BANK 2

Category	Representation of Model With the Lowest RMSE
Coin and Currency	NDDS on CC
Treasury Securities	TSTS on TS
Other Securities	OTD on OS
Total Loans	SAVDL on TL

TABLE L

LOWEST ROOT MEAN SQUARE ERROR
REPRESENTATION, BANK 3

Category	Representation of Model With the Lowest RMSE
Coin and Currency	TNSTS on CC
Treasury Securities	TNSTS on TS
Other Securities	OTD on OS
Total Loans	OTD on TL or TST on TL

TABLE LI

LOWEST ROOT MEAN SQUARE ERROR
REPRESENTATION, BANK 4

Category	Representation of Model With the Lowest RMSE
Coin and Currency	NDD on CC
Treasury Securities	SAVD on TS
Other Securities	OTD on OS
Total Loans	OTD on TL

TABLE LII

RESULTS OF HEURISTIC MODELS BY
BANK AND ASSET CATEGORY

Bank	Asset Category CC	TS	OS	TL
1	SAVD on CC	OTDS on TS	OTD on OS	TST on TL
2	NDDS on CC	TSTS on TS	OTD on OS	SAVDL on TL
3	TNSTS on CC	TNSTS on TS	OTD on OS	OTD on TL or TST on TL
4	NDD on CC	SAVD on TS	OTD on OS	OTD on TL

For bank 1, the results shown in Table XLVIII indicate that for three of the four asset categories, i.e., coin and currency, other securities and total loans, a form of the group allocation model yielded the lowest RMSE. These results show that bank 1 adjusted its asset portfolio according to changes in the total liability categories. The results for bank 1 indicate that the null hypotheses for hypotheses one, two and four should be accepted. The remaining two null hypotheses should be rejected and their alternatives accepted.

Table XLIX presents the results for bank 2. Three of the four asset categories make adjustments based on a form of the component allocation model. Coin and currency, treasury securities and total loans seem to be adjusted on the basis of a change in a short-term or long-term component for one of the liability categories. These results indicate that for hypotheses one, four and five the null hypothesis should be rejected and the alternative hypothesis accepted.

Table L gives the results for bank 3. Two of the four asset categories, i.e., coin and currency and treasury securities, have forms of the component allocation model which produce the lowest RMSEs. Two of the four asset categories, i.e., other securities and total loans, have forms of the group allocation model which produce the lowest RMSEs. These results indicate that bank 3 allocates funds to its short-term asset categories based upon the short-term and long-term components of changes in the liability categories. The results also indicate that bank 3 allocates funds to its long term asset categories based upon changes in the total long-term liability categories. For bank 3, hypotheses one and four should be accepted. The remaining null hypotheses should be rejected and their alternative hypotheses accepted.

The results for bank 4 are shown in Table LI. All four of the asset categories, i.e., coin and currency, treasury securities, other securities, and total loans, have the lowest RMSEs produced by forms of the group allocation model. These findings show that bank 4 allocated its funds to its asset categories based upon changes in the total short-term and long-term liability categories. For this bank the null hypotheses one and two should be accepted. The remaining null hypotheses should be rejected.

Table LII summarizes the best heuristic models by asset category. The best representations for the treasury securities category indicate that for three of the four banks a form of the component allocation model is the best. This indicates that banks 1, 2, and 3 allocate funds to the treasury securities category based on the short-term component of the change in one or more liability categories.

The same table shows that for the coin and currency category banks 2 and 3 allocate based upon forms of the component allocation model, and banks 1 and 4 allocate based upon forms of the group allocation model. It can therefore be concluded that for the coin and currency category there is no definite preference for either, i.e., group or component, type of model.

The other securities and the total loans categories are the remaining asset categories shown in Table LII. For the other securities category for all four banks, the best representations are a form of the group allocation model. These results indicate that all four banks allocate funds to this asset category based upon the changes in the total amounts of specific liability categories.

Almost the same results hold true for the total loans category. Three of the four banks, i.e., banks 1, 3 and 4, have forms of the group allocation model as their best representation for this asset category. These results mean that for the total loans category the majority of banks allocate funds based upon changes of the total amounts in a given liability category.

Table LII provides no new information about which hypotheses should be accepted or rejected. It simply provides a different format for examining the research results.

These results, while clearly indicating a heuristic, linear programming and quadratic programming ordering as far as the predictive ability of the three types of models are concerned, also reveal additional information. It is clear that the best heuristic model is very asset category and bank dependent. There is no one heuristic model whose results are consistently the best for all banks and all asset categories.

This result implies that of the four banks studied each behaves in its own way as regards the adjustment of its asset portfolio.

Implications of the Study

This research provides insight into two aspects of bank behavior. First, it provides information regarding the predictive abilities of various models of bank behavior. Second, the study provides information about how the four banks in this study adjust their asset portfolios.

This study shows that heuristic time series models are the best predictors of a bank's asset portfolio adjustment process. The results indicate the heuristic models to be more accurate predictors than the optimization models studied. The study also shows that the idea of filtering data, i.e., using a permanent or transitory component of the change in a particular liability category, does not always provide a more accurate prediction of the adjustment process. The implication of these findings is that both researchers and bank managers who are trying to predict asset portfolio adjustments would do better to model the behavior of a particular bank or banks using a heuristic time series model of the kind shown in this paper than they would to use either of the two optimization techniques studied.

The study also indicates how funds are transferred within the four banks examined. The results of the study show that the pool-of-funds concept of asset portfolio adjustment is not prevalent within the four banks. The implication being that in future research a pool-of-funds behavior could be ignored or given less emphasis than other theories of asset portfolio adjustment.

The adjustment process found to be the best for each bank and asset category varied widely among the four banks and the four asset categories for each bank. The implication of this result is that future researchers trying to establish heuristic time series models of bank behavior should be very careful in generalizing any results found for a particular bank or asset category.

The results of the heuristic models indicated both significant lead and lag coefficients. The implication is that the banks adjust their asset portfolios according to past deposit inflows as well as expected future deposit inflows. Future researchers would do well to incorporate the anticipated deposit inflows into their efforts.

Recommendations for Future Research

For this study, recommendations will only be made for future studies which would compare the predictive abilities of models of bank asset portfolio adjustment.

The recommendations for future research are threefold. First, additional optimization models could be used along with linear and quadratic programming. Goal programming and/or multiobjective programming might be two optimization methods for future consideration. Also, alternative specifications to the linear and quadratic programming models used in this study are also possibilities.

Second, the time series models specified in this study might be reformulated. Provided data is available, a mechanism allowing for liability management on the part of each bank might help increase the predictability of the time series models. A multistage autoregressive framework might be more accurate. If the multistage autoregressive framework allowed for a feedback or circular mechanism between the banks' asset adjustment and liability management, the accuracy of the predictions might be greatly increased.

Finally, a study might be conducted under different economic conditions than the current study. The April to October 1976 period for this study was a relatively stable period for the banking industry. Similar studies might be done in periods of large funds inflows and outflows for the banking industry.

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VITA 2

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